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Geological and Polytechnic Society.

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1895—1899.

WITH SIXTY-NINE PLATES.

EDITED BY

WILLIAM LOWER CARTER, M.A., F.G.S.,

AND

WILLIAM CASH, F.G.S.

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1899.

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OF THE

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NEW SERIES, VOL. XIII., PART I., pp. 1—133.

With Eight Plates,

and Ten Photographs of the Malham Dry Valley.

Edited by W. LOWER CARTER, M.A., F.G.S.,
and WILLIAM CASH. F.G.S.

1895.

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and WILLIAM CASH, F.G.S.

1895.

ON ANOTHER SECTION IN THE SO-CALLED INTER-GLACIAL GRAVELS OF HOLDERNESS. BY THOMAS SHEPPARD.

The Kelsey Hill Gravels, opened several years ago, are, I think, well known to all glacialists, but unfortunately the gravel pits at which Messrs. Phillips, Wood and Rome, Prestwich, Reid and others worked are now to a large extent overgrown, and nearly all the sections recorded by those gentlemen are no longer visible. When the gravels first began to attract the attention of geologists the general opinion was that they had been deposited during a *mild inter-glacial period*, during which a lower bed of boulder clay was to some extent denuded, and the range of gravel hills, of which Kelsey Hill is one, was formed from the material washed out of this clay. The scarcity of scratched stones and other similar evidences of ice-action being the ground for this supposition.* The few ice-scratched boulders noticed had the scratches almost entirely obliterated, and it was thought that these stones were first enclosed in the lower boulder clay, and the subsequent denudation was answerable for the grooves being removed.

The numerous animals, mammoth, deer, rhinoceros, bison, &c., the remains of which were found in the gravels, were also supposed to be the inhabitants of this area during the time between the two Glacial Periods.

---

* Prof. Prestwich on the occurrence of Cyrena fluminalis near Hull. Quart. Journ. Geol. Soc. vol. xvii., p. 455.

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More recently the late Professor Carvill Lewis visited these gravels, and, though he stated that there was a lack of evidence in support of an inter-glacial period, he expressed the opinion that "Kelsey Hill is not a mound, and has not the aspect of a moraine,"* and certainly the hills in question do not present the characteristic appearance so lucidly explained to some of us at a meeting of the Glacialists' Association, held at Birmingham last December (1894), when Mr. P. F. Kendall gave us the benefit of his work on the York Moraines.† In the "Geology of Holderness" it is stated‡ "About half-a-mile from Kelsey Hill, in the north-east continuation of the same gravel, there are two small pits" (*i.e.* in 1885).

The object of the present paper is to describe the sections exposed by more recent excavations, and to discuss by the aid of this new information the views expressed by earlier observers.

The most northerly exposure is now entirely worked out. A small section showing current-bedded chalky gravel, with shells and foreign stones, capped by six feet of reddish boulder clay, was all that was visible last summer (1894). The frost and rain of the past winter, however, by causing a large mass of boulder clay to slip over the gravels, have entirely covered up the lower portion of the section, leaving only a slope of boulder clay visible.

The other pit, locally known as the Burstwick Gravel Pit, has been steadily enlarging: the excavation of material for the lighthouse recently erected at Withernsea has greatly helped to give the section its present size.

The Burstwick Hill is broader than those of the same range to the north and south, and it has a flat top. The section is cut in from the eastern side of, and roughly at right angles to, the line of hills.

The gravel here is very similar to that at Kelsey Hill, and displays a similar variability in different parts of the pit. Towards the western side it is mainly sand, with a tongue of boulder clay intercalated in it in a most remarkable manner (A 1). This boulder clay is of a very red colour, has a peculiar serpentine form, is not more than a foot thick anywhere, and has a total exposed length of some eight feet. Just at the east of this several thin seams of boulder clay are seen intersecting the gravel and sand, in a net-like fashion (A 2). This boulder clay exactly resembles the tongue just described, though it is only in thicknesses of one to four inches, and the layers are bent and twisted in and out, following the curves of the sand and gravel. These seams of boulder clay are generally near the surface, and do not thrust into the gravel to the extent the previously mentioned tongue does.

---

* Glacial Geology of Great Britain and Ireland, p. 221.

† See also the Glaciation of Yorkshire. Proc. Yorksh. Geol. and Polyt. Soc., vol. xii., p. 306 (1893).

‡ Page 56.

A little further to the east, where the height of the section is about 20 feet, it has the following singular appearance :—

(*a*) The bottom consists of slightly inclined chalky gravel, then

(*b*) About one-third up is a layer of almost horizontally-bedded gravel nearly a foot thick, light coloured, and consisting of exceedingly fine particles, with a very large percentage of comminuted shells, which have the appearance of having been subjected to great pressure, as they are broken into pieces almost too small to be specifically identified, no doubt resembling the small crumb-like fragments sometimes observed in the Drift Hills of Flambro' Head.* Immediately above this layer, and resting on it at a high angle, are

(*o*) About three feet of coarse, earthy, ferruginous gravel, with a few shells, which, however, occur in fairly good condition.

(*d*) Above this there is a large mass of current-bedded sand, containing a few lenticular patches of gravel, with the thin seams of boulder clay, previously alluded to, near the top, and the whole is surmounted by

(*e*) A few inches of soil, probably weathered boulder clay.

This is a fair example of the appearance of the series. In some places layers of coal-like material are seen in the sand (C 2). There are too, here and there, large masses of gravel firmly cemented together in the form of conglomerate (B 1), the decomposition of ironstone pebbles possibly supplying the cement. In these patches each pebble has a ferruginous coating, which renders the identification of the rock itself impossible without the aid of the hammer.

---

*Drifts of Flambro' Head. Quart. Journ. Geol. Soc., vol. xlvii., p. 398. (1891).

Occasionally pebbles are cemented together, though in smaller masses, by a calcareous cement. The stones in this case have a coating of lime, which has in all probability been derived from the weathering of chalk or other limestone boulders above. As, however, the chalk and other pebbles in this pit have a very fresh appearance, I was at first disinclined to regard this explanation as satisfactory, until recently, when searching above one of these clusters of lime-coated stones, I had the fortune to find a boulder of chalk in a partially dissolved condition.

Now with regard to the stones: we have here as great a variety of rocks as could be hoped for in so small an area. The gravel consists mainly of small stones, varying in size from that of a pea to that of an egg; the larger boulders are generally found in layers, both pebbles and boulders in nearly all cases being well rounded.

There are several boulders of gneiss, granite, &c., used as curbs, in the village of Burstwick; no doubt some of them have been obtained from this pit. The following is a list of the rocks found here, in order of prevalence, those at the latter part of the list occurring only occasionally:—

Chalk and Flint (British, with Belemnitella quadrata).
Lias (with Ammonites communis and Gryphæ incurva).
Ironstone (? Liassic).
Black Flint (Foreign).
Pink Flint (Danish).
Carboniferous Limestone (Teesdale).
Brockram (Permian conglomerate, from Vale of Eden).
Porphyrite (from Fredericksvaarn).
Quartz-porphyry (Armboth dyke).
Basalt (Teesdale).
Quartzite.
Rhomb-porphyry (Norwegian).
Red Granite (Norwegian?).
Gneiss (Norwegian?).
Lava (Lake District).

I have not yet been successful in finding a piece of Shap Granite here, nor can I find any record of its having been noticed.

Several of the chalk boulders are well rounded and bored with Clionæ and Pholas crispata. The holes in the pebbles occasionally contain the shells in a perfect state of preservation, though sometimes sand takes the place of the shells. Other chalk pebbles are cracked from the centre outwards, in a similar manner to the cracks seen in septarian nodules.

The boulders of gneiss and schist are occasionally very rotten, breaking into powder at the stroke of the hammer. Some, however, are as fresh as if recently broken from the heart of a large block. No doubt the former boulders would be partially decomposed before being torn up from the floor by the ice.

There are no well-marked, ice-scratched stones. One or two, however, have been noticed, although the scratches were nearly obliterated owing apparently to the pebbles having been rolled in water.

Whilst digging at the gravel in almost the centre of the pit, at a depth of 16 feet, I unearthed a boulder of rhomb-porphyry (a characteristic Norwegian rock), well rounded, and about six inches long and four inches wide. The position of this boulder, 16 feet from the surface, and in central Holderness, *six miles from the sea*, is a good case wherewith to test Sir H. H. Howorth's hypothesis that these Norwegian boulders had been brought over to England as anchors by the evidently exceedingly industrious Vikings. See *Nature*, May 24th, 1894.*

The Shells.—These are found in different quantities and in various conditions (though they all have a waterworn appearance) in all parts of the pit. As already stated, in some places they are represented by minute fragments, whilst in others they are preserved whole. Cyrena fluminalis, Cardium edule, Tellina balthica, Ostrea edulis, and Buccinum undatum can be found in plenty. It will thus be seen that the shells here resemble those found at Kelsey Hill, both in species and numbers, though they are slightly different in the matter of relative prevalence.

---

* Since the reading of the paper I have found another example of rhomb-porphyry of even larger dimensions in the undisturbed gravel. The find can be attested by several members of the Hull Scientific Club, who saw the stone projecting from the face of the section 12 feet from the top, and firmly fixed in the ferruginous conglomerate before mentioned.

The following is a list of the shells I have been able to obtain up to the present. I do not doubt but that a more careful search will bring to light almost the whole of those that are recorded from Kelsey Hill.*

CONCHIFERA.

Astarte borealis, *Chemn.*
Cardium edule, *L.*
Cyprina islandica, *Lam.*
Cyrena (Corbicula) fluminalis, *Müller.*
Mactra solida (var. ovalis), *L.*
,, subtruncata, *Da C.*
Mya truncata, *L.*
Mytilus edulis, *L.*
Ostrea edulis, *L.*
Pholas crispata, *L.*
Tapes decussata, *L.*
Tellina balthica, *L.*

GASTEROPODA.

Buccinum undatum, *L.*
Fusus (Trophon) antiquus, *L.*
,, scalariformis (clathrata), *Gould.*
Littorina littorea, *Linn.*
Nassa reticulata, *L.*
Natica clausa, *Brod. and Sow.*
Pleurotoma turricula, *Mont.*
Purpura lapillus, *L.*
Scalaria communis, *Lam.*
Turritella terebra, *L.*

SOLENOCONCHIA.

Dentalium entalis, *L.*

CIRRIPEDIA.

Balanus crenatus, *Brug.*

Cyrena fluminalis is one of the most plentiful, and is by far the best preserved, as nearly every specimen is perfect, but it is worthy of note that I have never found an example with the valves in apposition, and I cannot find that any such specimen has been taken in this neighbourhood.

---

* Geology of Holderness. Page 70.

The occurrence of this fresh-water shell, mixed with the marine shells in these gravels has been the subject of much controversy, and has frequently been the cause of rather heated discussions amongst local geologists. A careful search through the literature on the subject showed that the presence of this shell had several times been recorded, but in not one single instance have I been able to find a satisfactory explanation of the same. In order to get this I was requested to write to Mr. P. F. Kendall, and his reply to the communication was gratifying to us all. As the purport of this letter has not previously been made public, the present seems a very fitting opportunity for quoting it, more especially as it is so relevant to the immediate purpose of this paper.

"Cyrena fluminalis is in two ways a puzzling shell: it is odd that its occurrence should be so limited, and it is still more strange that a shell at present so strictly southern in range should occur in such profusion in a glacial deposit."

"First, as to its limited glacial range in Yorkshire. I think that, as Clement Reid suggests, there *may* be some connection with the gap in the Wolds. At the present day the shell is of fluviatile habitat, and probably was mainly so in glacial times, but *bi*valve shells *are not* carried out to sea in large numbers by modern rivers, and therefore Reid's explanation, taken by itself, will not account for the profusion of these shells intermingled with true marine species. No more will it account for the *form* of the mounds in Holderness. These are not *marine* but *glacial* features."

"Now for a suggestion. We have every reason to believe that Holderness was invaded again and again by the oscillating ice-front. Between a retreat and an advance there would be left a tract of land with many lakelets. May not Cyrena have inhabited some of these, and been involved at the next invasion with the marine shells dragged up by the ice? That's one suggestion. Another, and to me more probable hypothesis is that these shells belong to a period before the first advance of the Norse Ice. At this time the old Humber would debouch somewhere on Holderness (there would be a great beach and other deposits along the coast then which may have modified the estuary), and in its estuary the Cyrena would flourish among *some* marine shells as the genus flourished in Eocene times in the south of England among oysters and other marine species. Now bring in the ice with its entangled marine shells, mingle the whole together, and you have the Kelsey Hill Gravels as the washings. It is worth bearing in mind that there is evidence that, at some period before the ice invasion, the country stood higher than at present and therefore the mouths of rivers would stand further seaward."

"Now as to the value of the shell as evidence of climate. The oft-cited case of Cyrena fluminalis has long been regarded as one of the most conclusive proofs of a warm inter-glacial period in Holderness, as in other parts of England. You will find in all text books the statement that the species occurs in the Nile, the implication being sometimes explicitly stated that it is found nowhere else. Were this actually the case the shell would, I think, undoubtedly furnish evidence hard to controvert of the prevalence of a warm climate in Britain at the time when Cyrena fluminalis was an inhabitant of our rivers. It has, however, long been known to conchologists that the species lives in the rivers of Sicily, a fact of great significance, as many of the Sicilian streams are fed by melting snow, and are therefore, at certain times of the year, but little above freezing point. A yet more important extension of the known range of the shell however has been brought under my notice by Mr. J. W. Taylor, of Leeds. He says :—'It would seem to be a general inhabitant of 'N.E. Africa and Central and Western Asia; these latter are on the 'authority of Professor von Martens, one of our very best conchologists. (Samarcand and the River Oxus are two places mentioned).'"

"We have here a series of facts which in my judgment quite dispose of Cyrena fluminalis as evidence of an inter-glacial period or of warm condition. Though it is the custom to regard the arid deserts of Turkestan as regions of torrid heat, it must not be forgotten that they experience winters of great severity, and an examination of the "Challenger" charts shows that the January isotherm of 30°F. passes a little to the northward of Samarcand, which, therefore, has a winter similar in severity of cold to that of Cape Farewell, the southernmost extremity of Greenland, and to that of the south coast of Iceland."

"These facts harmonise entirely with the opinion which I formed long ago, based upon the fact that at Crayford shells of Cyrena fluminalis are found in the same deposits of Brick Earth that have yielded remains of the Mammoth, the Woolly Rhinoceros, and the Musk Ox, and I have myself found them in the same inch-thick layer that yielded me dozens of bones and teeth of the Siberian Vole, Arvicola ratticeps."

Mammalian Remains.—At one of the Field Excursions of the Hull Scientific Club in this neighbourhood two or three years ago, one of the members obtained two pieces of bone from the workmen, which at that time were thought to be the remains of the Mammoth. This find impelled me to pay regular visits to this and other gravel pits in the district, which, however, until recently, were without much result.

During the past winter on calling here, the men had saved for me a vertebra of Cervus megaceros, a piece of horn of a ruminant which we cannot at present identify, and another piece of bone. I was also told that Mr. Webb, of Burstwick, had several bones from these gravels, and on going to see that gentleman, he kindly handed them over to me, with the exception of the right radius and ulna of a horse (Equus caballus). As these latter specimens have a fresh appearance, with all the articular surfaces preserved, and they are neither waterworn nor do they possess the peculiar red colour so characteristic of the bones found in these gravels, I am inclined to think that they have nothing whatever to do with the gravels, but belonged to an animal which lived at a comparatively recent date; more especially as they were *found near the surface.*

The other specimens are chiefly small, and in a very fragmentary condition. They consist mainly of parts of ribs and other equally undeterminable portions, some of which are so much waterworn as to resemble pebbles.

At the beginning of this year on visiting the pit, I was fortunate enough to find the left radius and ulna of Bos taurus. This I took from the gravel close to the floor of the pit. Inside this specimen was a small quantity of light-coloured, plastic clay, totally different from the neighbouring boulder clay. There is also a peculiar mark in the centre which appears to have been made by the tooth of some carnivore. It is also fractured inside as though partially bitten through. There are, too, several small marks on the face of the bone which give it the appearance of having been gnawed. The conditions under which the specimen was found render it impossible for it to have been struck by the workmen. The dendritic markings of manganese covering the impression also seem to indicate that the indentation in the bone was made prior to its deposition in the gravel. The upper part of the ulna is broken away just opposite the mark, and appears to have been torn off by the same bite as made the indentation.

It would seem probable, therefore, that this bone, after having been gnawed, had been left in the bed of a stream or on the beach (in a similar manner to those described by Mr. Lamplugh when the Sewerby Cliff Gravels were opened)[*] to be finally lifted up by the ice, along with the other material from the beach, and deposited at Burstwick.[†] It will be noticed that the mammalian remains are only found in those hills south of Bridlington.

The following is a list of the animals whose remains have been found in the Burstwick Pit :—

Cervus megaceros.
,, elephus.
Bos primigenius.
,, taurus.
Hyæna (?). (Indicated by gnawings.)

These have been identified by Mr. H. M. Platnauer, B.Sc., A.R.S.M., who states that there are also remains of at least three other species of animals not yet identified.

The workmen tell me that bones are generally found when they dig deep down into the gravel.

The Boulder Clay.—On the western side[‡] of this pit there is a bed of reddish boulder clay (A), containing very few pebbles. It is about eight feet thick and rests on the gravel, bifurcating towards the east, one tongue thinning out on the top of the gravel, and it may be that the tongue of red boulder clay in the sand previously mentioned, is part of the lower portion of this bed, although at present it is impossible to ascertain definitely.

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[*] Proc. Yorksh. Geol. and Polyt. Soc., 1887, Buried Cliff at Sewerby, p. 381.

[†] These bones may have been left by the animals inhabiting this region during the oscillation of the ice-front.

[‡] Since the paper was read the boulder clay has been exposed on the eastern side of the pit, capping the gravel.

This red boulder clay is not nearly so compact as the purple boulder clay of the coast nor the basement clay of Bridlington and Dimlington, and the view has been put forward by some glacialists that it may be "the residuum left behind on the melting of a sheet of ice charged with clay and stones."* The fact that this clay is exposed more to the weather may, however, partly account for its being more friable than the under-lying boulder clays. On the other hand, the superior hardness of the other clays may perhaps be due to their having been subjected to a greater pressure of superincumbent ice during or since their formation.

Mr. Lamplugh's explanation will account for the peculiar manner in which the clay *flanks* the gravel, and also explains how it is that this red boulder clay (the Hessle Clay of Wood and Rome) extends beyond the limit of the rest of the drift.†

The various boulders‡ found in the gravel seem to indicate that the Norweigan ice-sheet on coasting along our shores first passed the mouth of the Tees (the Teesdale Glacier having brought down Shap granite, Armboth dyke, Brockram, Carboniferous Limestone, &c.); then the Lias of Whitby (from which the Ammonites and Gryphæ incurva were obtained), afterwards the Chalk at Flambro', and then dragged with it the greater part of the beach of the pre-glacial Bay of Holderness, with its pholas-bored chalk-pebbles, bones, &c., and finally deposited the whole, mixed with the Scandinavian rocks and marine shells, together with the fresh-water Cyrena, so as to form the range of hills stretching from Flambro' to Paull and on into Lincolnshire, this being its terminal moraine.

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* Lamplugh, Drifts of Flambro' Head. Quart. Journ. Geol. Soc., vol. xlvii., p. 424, (1891).

† Ibid. Page 424.

‡ Of course some of these boulders were probably scattered over a sea bottom before being picked up by the ice-sheet. See Quart. Journ. Geol. Soc., sup. cit., p. 410.

Mr. Lamplugh seems to be of opinion* that the Teesdale Glacier skirted along our coast during a retreat of the Norse ice (the front of this ice-sheet diverting the Teesdale Glacier's course southwards). The opinion is also expressed,† however, that having regard to the enormous time the Norwegian glacier would take to reach England, the Irish Sea would have had ample time to have been choked with ice, thus diverting the ice from the Lake District down the Valley of the Tees, which would carry with it the Shap granite and other rocks *before* the foreigner reached us.

Regarding peculiar beds of carbonaceous matter seen in the sand Mr. Lamplugh wrote that perhaps "the sea was not entirely excluded from the old bay, and in some places laved the edge of the glacier . . . just as the sea re-sorts the morainic and fresh-water gravels on the flanks of the Muir and other glaciers in Alaska."‡

The current-bedding in the gravels would easily be accounted for by the water flowing from the ice-front; or the sea washing against them (as already mentioned), and the boulder clay being both under‖ and above the gravels seems to indicate that the gravels have been over-ridden, perhaps more than once, by the oscillating ice-front. The thin beds of boulder clay mixed in the gravel, together with the kneaded-out aspect of the hills, also favour this view.

The fact that this is a terminal moraine does not indicate that it represents the limit of the Norse ice, nor is it of necessity the only moraine of this glacier, as we have good reason to believe that, like the Vale of York glacier, this Norwegian ice-sheet has left us more than one moraine, as monuments of its former existence.

The contour of the Holderness Hills is very striking and totally different from anything else in the country. Here and there are ellipsoidal hills, generally about fifty feet in height, occasionally quite detached, and once or twice, as at Burstwick, two hills appear to have been kneaded into one, although this appearance may be due to one hill having been flattened out. Swamp hollows are enclosed amongst these hills.*

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* Lamplugh, Drifts of Flambro' Head. Quart. Journ. Geol. Soc., vol. xlvii., p. 424, (1891).

† Kendall, Glaciation of Yorkshire. Proc. Yorksh. Geol. and Polyt. Soc., vol. xii., p. 315.

‡ Drifts of Flambro' Head. Page 422.

‖ Indicated by borings.

A few words may not be out of place here on the subject of the vexed question of a marine submergence during an inter-glacial mild period. In the first place the fact that these gravel mounds repeat the features of and are a continuation of the moraine of Flambro' Head is a strong argument against their marine origin. The intercalation of boulder clay, a material quite unlike any modern marine deposit of the Arctic seas, is another fact which tells strongly against this hypothesis. Then there are the further difficulties that no beaches or marine deposits have been found on the Chalk-wolds, or in the country west of the Wolds, where they should occur on the assumption of a submergence.

It may be noted that Mr. Clement Reid recognised this difficulty when he put on his map of Inter-glacial Holderness† the words "No fossiliferous marine gravels *yet* known over this area." I have italicised the word "yet" for Mr. Reid seems to imply that such gravels probably exist though they have not *yet* been found. It does not appear to me probable that after the mapping of the whole area both for Drift and Solid by Mr. Reid and his colleagues, together with the careful work of many other observers, has failed to detect *any* sign of marine action, that there is much probability in the suggestion that marine fossiliferous gravels will be found. The hills of the Burstwick range have the disposition, composition, and contents which have been described as characterising other moraines, and saving the occurrence of shells they have none of the features of a marine deposit.

As to the shells themselves, I am given to understand that saving Corbicula fluminalis they constitute a fairly natural assemblage, but their condition is conclusive proof that they did not live where we find them, and the many evidences which have been described by Mr. Lamplugh, Mr. Reid and others, of the transport of shells by glacier-ice and their inclusion in morainic deposits, justifies me in rejecting them as evidence of the marine origin of these deposits.

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* See Kendall's Glacial Geology of Isle of Man, Yn Lior Manninagh, vol. i. No. 12, p. 9, 1894, for definition of terminal moraine of an ice-sheet.

† Geology of Holderness, p. 65.

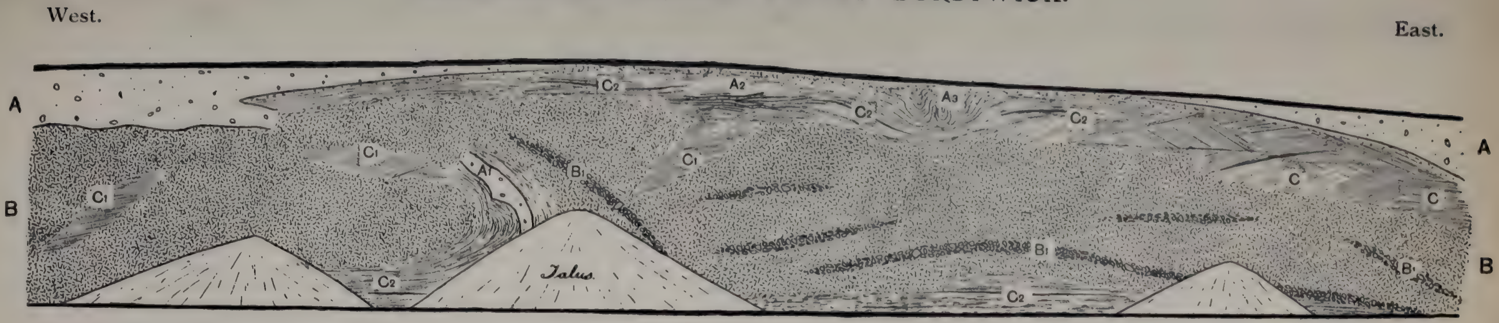
If, as pointed out in Mr. Kendall's letter, the ice-sheet oscillated over this area repeatedly, then it is quite conceivable that Cyrena fluminalis may have lived either in lagoons amongst the moraines, or perhaps even during the many deviations in the course of the Humber, produced by morainic obstructions, they may have lived in a portion of that river itself when it flowed across the site of the present Holderness.

Mr. Reid has pointed out in the case of Kelsey Hill that it lies directly opposite the gap in the Wolds through which the Humber flows and probably flowed.

Granted that these shells were either inhabitants of the area or that they were washed out to sea, their inclusion amongst the shoved-up contents of these Burstwick gravels is easily explained. It may be worth noting that the species has been found in the truly marine Red Crag, but there is associated with beautifully preserved marine shells with paired valves, which obviously lived on the spot.

In conclusion, I may be allowed to sincerely thank Mr. Kendall for permission to make use of his letter, as well as for valuable assistance in other directions; and also Mr. Platnauer, who was put to no small amount of trouble in identifying the mammalian remains.

SECTION OF GRAVEL PIT AT BURSTWICK.



DESCRIPTION.

Length of Section about 150 feet. Average height 25 feet.

A.	Red boulder clay with few small stones.
A.1.	Tongue of red boulder clay in gravel.
A.2.	Thin streaks of boulder clay in gravel.
A.3.	Contorted chalky clay. Chalky material no doubt being a crushed boulder of chalk.
B.	Chalky gravel, with shells and foreign stones.
B.1.	Layers of large boulders in gravel; generally cemented together.
C.	Current-bedded sand with many crushed shells.
C.1.	Irregular beds of sand in gravel.
C.2.	Streaks of carbonaceous material in sand.

Proc. Yorkshire Geol. & Polyt. Soc., Vol. xiii., *Plate* 1.

GLACIAL PHENOMENA NEAR YORK. BY C. FOX-STRANGWAYS, F.G.S.

Read 26th April, 1895.

Although many accounts of the glaciation of different parts of this county have appeared from time to time, very little has been written of its great central valley. Allusions to the district have frequently been made in treating of larger areas; but until quite recently, as far as I am aware, no one has attempted to describe or explain in a comprehensive manner the peculiar nature of the glacial beds of the neighbourhood. This is the more to be wondered at, as the features assumed by the drift around York are some of the most striking and remarkable of any part of England.

In the Explanations of the Geological Survey, published between 1873 and 1886*, a general description is given of the boulder clays, sands, and gravels that occur throughout the Vale of York; but, this not being the place to enter into controversial subjects, merely a description of the beds is given sufficient to explain the maps without any theory being propounded to amount for the manner of their distribution.

In 1881 Mr. Clark communicated a paper to this Society in which he gave a very detailed account of the glacial sections that were exposed in and around the City of York, and attributed the deposition of the beds chiefly to the agency of floating ice.†

It was not, however, till last year that a fairly comprehensive study of the glaciation of the district appeared, firstly in the notes of the late Prof. Carvill Lewis, published posthumously;‡ and secondly, in an important paper given to this Society by Mr. Kendall.‖ In the first of these Prof. Lewis, although his notes were hastily made during a rapid traverse of the country, appears to have at once grasped the main features of the district, and accounts for their formation in a manner which fits in satisfactorily with the main facts of the case. The chief points of his argument were that there was only one glacial period during which there were several large glaciers that covered the northern part of these islands, but which did not extend so far south as had been supposed by previous observers. The deposits occurring to the south of this were attributed to floating ice, and were supposed to have been laid down in a series of extra-morainic lakes that covered a large part of the central and eastern counties. This large ice-sheet or series of glaciers descending from the north, the exact origin is immaterial to the present enquiry, was separated into several streams, the courses of which are clearly marked by the distinct character of the erratics which they contain. The most easterly of these, coming from Scandinavia, impinged against the English coast, and was deflected by it as far south as the northern part of Lincolnshire; while another coming from Scotland by way of the Irish Sea was split up by the high ground into several lobes. One of these, easily recognised by its containing blocks of the peculiar granite from Shap, passed over Stainmoor, and was again divided by the Cleveland Hills; one part, passing to the north of them and meeting the great Scandinavian glacier, was deflected down the coast; while the other, probably owing to the pressure derived from the impact, was forced down the Vale of York; and, being joined by a branch coming out of Wensleydale, gave rise to the phenomena with which we are now more particularly concerned. The Wensleydale branch, which is characterized by the absence of Shap granite or any erratics except of such rocks as occur in the valley of the Ure, came down Wensleydale; and, meeting the larger ice-sheet to the east, was deflected southwards to the Nidd and the region about Harrogate. That these several glaciers were split up in this manner, and followed the courses indicated above, there is abundant proof in the physical character of the country and in the distribution of its glacial beds.

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* Memoirs of the Geological Survey. Explanation of our published Maps, 93 N.W.; 93 N.E.; 93 S.E.; 96 N.W. and S.W.; and 104 S.W., S.E.

† Glacial Sections at York, and their relation to later Deposits, by J. Edmund Clark. Proc. Yorksh. Geol. Soc., vol. vii., pp. 421-439, 1881.

‡ Papers and Notes on the Glacial Geology of Great Britain and Ireland, by the late Henry Carvill Lewis. Edited by Henry W. Crosskey, 1894.

‖ The Glaciation of Yorkshire, by Percy F. Kendall. Proc. Yorksh. Geol. Soc., vol. xii., pp. 306-318, 1894.

The total absence of glacial deposits or striations over the whole of the high ground formed by the Jurassic rocks in the north-east part of the County* clearly shows that these hills stood up as a buttress between the two streams of ice which piled up their deposits of clay and gravel on either side. With the exception of the northern portion of these hills, and a narrow band along their eastern flank, no superficial beds have been found except the few patches of drift marked on the map, and which are all of a local character. On the eastern side, the existence of a large sheet of ice is shown by the morainic mounds which have been heaped up along its edges, and which attain a height of 400 feet at Reighton and 600 feet on Seamer Moor; and also by the blocking up of the old valleys in this part of the county, which has in many cases completely changed the original courses of the streams and reversed their flow. This is, however, rather beyond the ground we are now considering, and, as I have gone into the subject in some detail elsewhere, it is needless to say more about it now.*

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* G. Barrow, Memoirs of the Geological Survey. Explanation of 104 S.W. and S.E., pp. 65, 66.

On the western side of the Jurassic hills the most striking evidence of the presence of an ice sheet flowing to the south is the gradual decline of the glacial deposits from 800 feet on the northern hills to 400 feet opposite Thirsk, and not more than 200 feet to the north-east of York, where they terminate in a series of mounds and ridges, which it is the purpose of the present meeting of the Society to investigate.† To the south of these mounds there is a complete alteration in the character of the superficial beds, and although there is a good deal of drift here and there, it is largely of a local character, consisting mainly of Chalk and Liassic gravel, which is found in great quantity capping the low hills from Stamford Bridge southwards to the Humber.

The manner in which these extra-morainic beds were laid down is, however, a question that is as yet far from settled, and we require to know a good deal more of their nature before propounding a theory that will suit all the requirements of the case. I am at present engaged in examining a portion of these beds in the Midland Counties, and I hope at some future date to be able to offer an opinion on the subject.

So much for the general conditions which may have given rise to the distribution of the glacial beds; let us now see how far the evidence in the neighbourhood of York bears out the supposition.

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* Trans. Leicester Lit. and Phil. Soc., vol. iii., p. 333, (1894).

† There is very little true boulder clay above 600 feet on these hills; above this level the drift is more gravelly and of a local character. Barrow, loc. cit.

It was one principle put forward by Professor Lewis "that every glacier at the time of its greatest extension is bounded and limited by a terminal moraine." This principle is well exemplified throughout Yorkshire, and perhaps nowhere better than near this city, where the moraine, which terminated what we may call the York Glacier, is situated. This moraine forms two more or less parallel mounds of boulder clay and gravel, which extend across the lower ground in a north-easterly direction, the one from York, the other from Escrick. They form most striking features in the great plain of York, and are very conspicuous in the maps of the Geological Survey and in that accompanying the paper by Mr. Kendall. These ridges are between two and four miles apart, and rise to an elevation of about 50 feet above the flat country on either side.

The main points insisted upon by Professor Lewis are in accordance with the observations made by the Geological Survey, and, I believe, are accepted by Mr. Kendall; but there are one or two statements made by the latter about which I should like to offer a few observations. In the first place, there appears to be a slight misunderstanding as to the exact meaning of the colours used on the official maps. The areas coloured blue are not entirely stiff boulder clay or till. They frequently contain sandy streaks and patches that are too small and irregular to map, and larger areas of gravelly drift that are too clayey to be considered a gravel. In these maps the distinct patches of sand and gravel are separated out, but the rest of the drift is thrown in with the boulder clay, and consequently the blue colour includes much that may be considered morainic. No distinction is made either between true boulder clay with erratics and local drift, so that it does not follow that all the areas coloured blue are true boulder clay.* I have been induced to offer these remarks as some exception has been taken to the mapping of the drift in this district.

Mr. Kendall, in alluding to the mounds at York and Escrick, raises the question as to which is the older of the two, and, contrary to natural supposition, inclines to the view that the northern or York ridge was formed first. As to their relative age, the distance between them is so slight, considering the great extent of this glacier, which must have been over 100 miles in length with an average width of 20 miles, that one would be inclined to regard these two mounds as practically part of one and the same moraine. If the valley was stripped of the more recent superficial beds which now cover it, there is little doubt that several other parallel ridges would be discovered both to the north and south of those that are now exposed ; and it is very probable that the isolated mounds of drift seen here and there in the vale are portions of such mounds just appearing through the thick covering of later beds. If such is the case, it would be natural to suppose that the most southerly ridge is the older, and the more northerly the younger, or as Mr. Kendall says "a moraine of retrocession."

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* This applies to the drift in the southern portion of the Vale of Pickering and other places, which Mr. Kendall regards "with a good deal of suspicion."

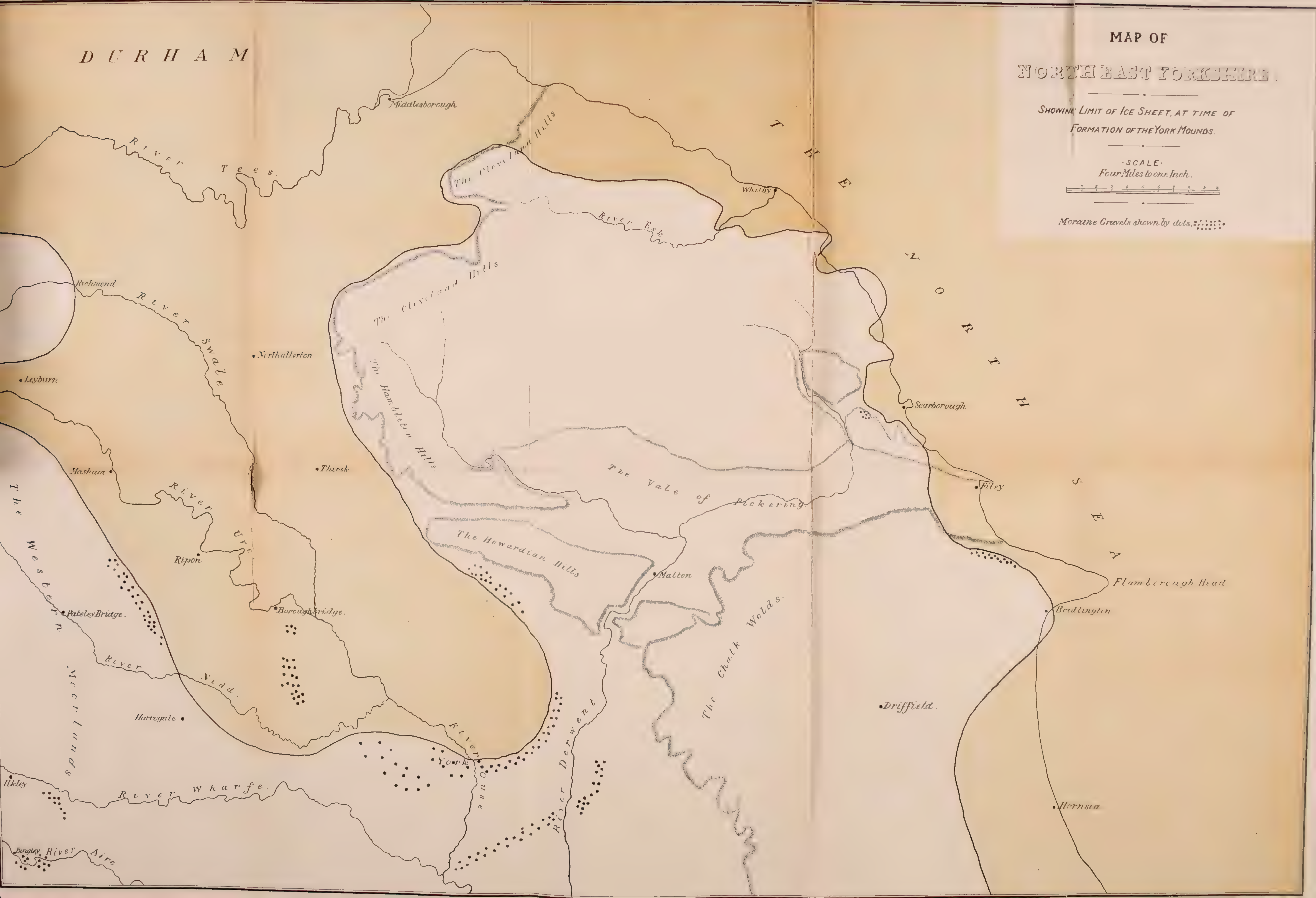
Of the internal structure of these ridges we know very little. The sections about York frequently show highly contorted beds of clay and sand, proving that great pressure has been exerted against them since their first deposition, and it is very probable that many of the out-crops marked on the map are due to similar contortions. The fact of clay being now seen at the surface is no proof that the glacier over-rode the moraines, "plastering their inner and outer faces with clayey ground moraine."

Mr. Kendall seems to see no difficulty in a glacier of this size overriding its moraine. Such a glacier I admit may have passed over the spreading beds of drift to the west of York, but I cannot conceive it passing over the narrow ridge to the east without dispersing the materials and entirely obliterating its character as a ridge. It has been objected that a great part of these mounds is too clayey to be moraine ; but we must bear in mind that this glacier at one time probably extended much further to the south, and also that the valley to the north undoubtedly contains a good deal of true boulder clay ; a portion of which would be borne forward by the glacier, and mixed with the more gravelly morainic material at its terminus. Until a better section has been exposed of the internal arrangement of these mounds it is not possible to be sure of the exact sequence of events which brought about their structure.

It is now many years since I had an opportunity of seeing these beds, but on reference to my notes I find that very few sections were to be seen in stiff boulder clay. In several places boulder clay was observed overlying gravels, but it was generally more or less of a morainic character, and frequently so nearly approaching a gravel that it was difficult to decide how it should be represented on the map. There is no evidence that the gravel in these mounds forms "the crest of a ridge against which the boulder clay was banked ;" and consequently no necessity for supposing that the ice passed over the mounds.

In conclusion let me observe that the idea, propounded by Prof. Lewis to explain the formation of the drift, of several glaciers emanating from the north and pushing over the country in a series of tongues, is that which best accounts for the phenomena to be observed throughout the county ; and that, in spite of the objections that have been raised against it, there is no other theory that so nearly meets all the facts of the case. These objections it will be the duty of the present meeting to examine, and endeavour to find out how far the difficulties are capable of solution.

NOTE.—Since the above went to press Mr. Kendall has intimated that I have misunderstood his views as to the relative age of these mounds, and that he particularly desired to avoid any expression of opinion on the point. A perusal of Mr. Kendall's paper certainly gave me the impression that he was *inclined* to regard the York moraine as the older of the two, although he distinctly leaves the question open for further investigation. C. FOX-STRANGWAYS.



MAP OF

NORTH EAST YORKSHIRE.

SHOWING LIMIT OF ICE SHEET, AT TIME OF FORMATION OF THE YORK MOUNDS.

·SCALE·
Four Miles to one Inch.

Moraine Gravels shown by dots.

CENTRAL PARK
NATURAL HISTORY

LAKE-DWELLINGS IN THE VALE OF PICKERING. BY J. SPINK.

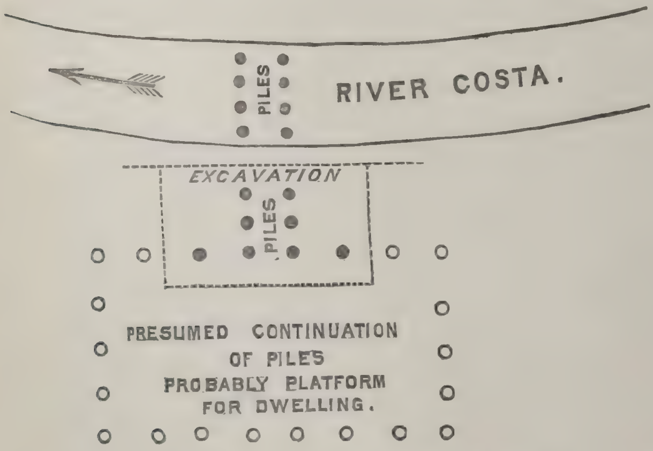
(*Read 26th April, 1895.*)

The Vale of Pickering, or, as it is sometimes called by geologists, Pickering Lake, is an alluvial plain, bounded on the north and west by the North York Moors and their off-shoots, and on the south and east by the Yorkshire Wolds. It is about eighteen miles long from east to west, and has an average breadth of eight miles. At some period it has been a lake, whose waters found an outlet into the sea by the valley at Scarborough, and by the Hertford Cut at Filey. It is now drained by the Derwent and its tributaries, which escape into the Ouse drainage district through a gap between the Wolds and the Howardian Hills at Huttons Ambo Station. The southern portion is known as the Marishes (Marshes).

One of the tributaries of the Derwent, on the western side, is the Costa, which rises in Keld-Head Spring from a fault of the limestone meeting the Kimmeridge Clay half a mile to the west of Pickering, a good stream of the purest water, and of such volume as to work two flour mills within a mile of its source. It flows south-west and south for four miles, receives Pickering Beck at Kirby-Misperton Bridge, and joins the Rye just above Howe Bridge, three miles to the north of Malton. About two hundred years ago the present channel was made to confine its waters; before then it must have spread over the land to a considerable distance, as the left bank is for the first mile much higher than the adjacent cultivated land. This, it may be presumed, was the last remnant of the pre-historic lake.

On several occasions, during the annual process of mowing the weeds and clearing the bed of the stream, many bones of animals and one human skull have been drawn out. This circumstance led Mr.

Mitchelson to look into the matter more closely, and four years ago, besides a great quantity of animal remains, he recovered from the bottom many pieces of coarse pottery, which, when broken, showed under the glass minute particles of crystal, caused by the action of lime in water on charcoal or ashes in clay. He also noticed several places where the tops of piles protruded just above the bed of the stream. These were two miles from Keld Head, and extended over a distance of half a mile. Wishing to be sure as to the value of the find, he sent a collection of bones and potsherds to the South Kensington Museum, through Captain Duncombe, and they were pronounced to be from the midden-steads of lake-dwellings. Thus encouraged he, two years ago, attempted a systematic search. Several excavations were made on the bank, and similar remains were found to those which had been taken from the river, only in much greater quantities. One illustration will suffice :—


PILES
RIVER COSTA.
EXCAVATION
PILES
PRESUMED CONTINUATION OF PILES
PROBABLY PLATFORM FOR DWELLING.

It was expected that the piles (four or five feet apart) which crossed the stream would be continued under the bank ; and at six feet below the surface they were again met with, and alongside were large quantities of bones of Bos longifrons, horse, deer, wolf (or dog), and sheep, along with crumbled twigs, nuts, &c. These extended two feet downward, after which was a layer of grey sand lying upon Kimmeridge Clay, and below this nothing was found. It should have been mentioned that the whole distance to the grey sand consisted of a dark brown (nearly black) peaty soil, the lower half being almost entirely peat.

From the side of one of the diggings, about four feet from the surface, many bones of a young person were taken, the vertebræ and skull with the feet and hands, being the only portions missing. Near this was found a small and beautifully-shaped jar of fine black clay, sound, and in good preservation, and two pieces of deer's horn—probably neck ornaments, one flat, of a crescent shape, and perforated with five holes; the other a portion of a tine with a hole penetrating the broad end. In another place, at about the same depth, was a piece of fine black pottery, bearing the only attempt at decoration found, in the form of drops on the outside, about the size and shape of the pip of an apple.

The pottery from the lower strata consisted of nearly sixty different patterns of jars or urns, ranging from six to about eighteen inches in height when complete, and many of them having what are called in this district *lugs*. This was of a very coarse kind, exhibiting plenty of thumb-marks, and evidently not turned on a wheel.

There were a great many pins, made of splint-bones sharpened, and several pieces of bone ground flat, and in shape like a knife. A piece of wood was also unearthed like the handle of a child's toy spade, and having a hole diagonally bored just below the fork.

A large number of pebble stones from two to four inches in diameter, nearly all split, and bearing distinct marks of fire, were evidently *pot-boilers*. There do not seem to have been any metal cooking utensils, or these stones would not have been required. Neither do the people seem to have had many (if any) metal tools, for on removing one of the piles it was found to have been sharpened in a very clumsy way, seemingly by wedges, first an outer layer and then a shorter piece, until the timber came to a rough point.

The neighbourhood of Pickering has long been known as a very prolific field for antiquarian research, extending as the remains do far back into early British times, every step in the process being clearly marked ; and we believe the discoveries which are here feebly described, carry the record much farther back into the misty past of aboriginal Britain.

NOTE.—Since the above was written Professor Boyd-Dawkins has visited the site and examined the remains, among which he discovered several human bones, and these he believed to have belonged to a race possessing the power of grasping with their toes. Some of these bones had been gnawed by dogs. He declared the find, as a whole, to be the most interesting that had come under his notice.

ON THE FOSSIL FISHES OF THE UPPER LIAS OF WHITBY. PART I.

BY ARTHUR SMITH WOODWARD, F.L.S., F.G.S., OF THE BRITISH MUSEUM (NATURAL HISTORY).

PLATES III.–V.

The fish-fauna of the Upper Lias has hitherto been most exhaustively studied in Germany and France. Although the cliffs in the neighbourhood of Whitby have continually yielded numerous specimens of fossil fishes since the days when Young and Bird* first identified petrified "pikes" (*Lepidotus semiserratus,* Agassiz) these have received only superficial notice in comparison with the corresponding fossils from the Upper Lias of Würtemberg, Bavaria, and France. Five species from Whitby were briefly described and several others named by Agassiz in his great work on fossil fishes, half a century ago†; Simpson‡ and Egerton‖ each subsequently recognised an additional species; in 1876 Blake§ published a list of the fauna without making any additions, contributing only brief notes and unsatisfactory figures of two species; still more recently the present writer has described *Gyrosteus mirabilis*¶ and recorded the occurrence of *Pholidophorus germanicus.*** In Germany, on the other hand, Quenstedt†† and Wagner‡‡ have published much more extended and exhaustive studies of the Upper Liassic fishes from Boll, Ohmden, Holzmaden, and other localities in Würtemberg and Bavaria; while Sauvage has undertaken similar researches in France, issuing several memoirs with technical descriptions and beautiful illustrations.* It is the object of the present memoir to extend our knowledge of the Whitby fossil fish-fauna if possible to a like degree, and to make detailed comparisons with the results of the Continental authors.

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* Young and Bird, Geological Survey of the Yorkshire Coast, p. 261, pl. xvi., figs. 7, 8 (1828).

† L. Agassiz, Reçherches sur les Poissons Fossiles, vol. ii. (1833-44).

‡ M. Simpson, The Fossils of the Yorkshire Lias, ed. i., p. 19 (1855).

‖ P. M. G. Egerton, Figures and Descriptions of British Organic Remains, decade vi. (Mem. Geol. Surv., 1852), no. 3 (*Lepidotus pectinatus,* Eg.)

§ J. F. Blake, in Tate and Blake, The Yorkshire Lias, pp. 255-260 (1876).

¶ A. S. Woodward, On the Palæontology of Sturgeons, Proc. Geol. Assoc., vol. xi., pp. 32-36, figs. 2-7 (1889); also The Fossil Sturgeon of the Whitby Lias, The Naturalist, April, 1890.

** A. S. Woodward, *Pholidophorus germanicus:* an Addition to the Fish Fauna of the Upper Lias of Whitby, Geol. Mag. [3], vol. viii., p. 545 (1891).

†† F. A. Quenstedt, Die Flözgebirge Würtembergs (1843, and ed. ii., 1851); Ueber *Lepidotus* im Lias e. (1847); Handbuch der Petrefaktenkunde (ed. i., 1852; ed. ii., 1867; ed. iii., 1883); Der Jura (1858).

‡‡ A. Wagner, Die Griffelzähner (Stylodontes), und zur Characteristik der Gattungen *Sauropsis* und *Pachycormus* nebst ihren Verwandten, Gelehrte Anzeigen k. bay. Akad. Wiss, vol. 50, pp. 81-100, 209-227 (1860); Bemerkungen über die Arten von Fischen und Sauriern, welche im untern wie im obern Lias zugleich vorkommen sollen, Sitzungsb. k. bay. Akad. Wiss. (1860), pp. 36-44.

For the purposes of this memoir the unique collection in the British Museum is almost sufficient, comprising, as it now does, the great collections of the late Sir Philip de Malpas Grey Egerton and the late Earl of Enniskillen. The fine series of specimens, however, in the museums of York, Whitby, Scarborough and Malton, have also been carefully examined and utilized, thanks to the respective curators of those museums; and the writer is especially indebted to the kindness of Messrs. J. F. Walker, H. M. Platnauer, Newbitt, Rowntree, and S. Chadwick for the facilities he has enjoyed.

Family Leptolepidæ.

Leptolepis saltviciensis, Simpson.

Plate III., figs. 1-5.

1844. *Leptolepis filipennis*, L. Agassiz, Poiss. Foss, vol. ii., pt. ii., p. 134 (name only).
1855. *Saltviciensis,* M. Simpson, Foss. Yorksh. Lias, p. 19.
1876. *Leptolepis saltviciensis*, J. F. Blake, in Tate and Blake, Yorksh. Lias, p. 260, pl. iii., fig. 1.
1884. ,, ,, M. Simpson, *op. cit.*, ed. 2, p. 16.
1895. ,, ,, A. S. Woodward, Catal. Foss. Fishes, B.M., pt. iii., p. 505.

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* H. E. Sauvage, Essai sur la Faune Ichthyologique de la Période Liasique suivi d'une Notice sur les Poissons du Lias de Vassy, Biblioth. Ecole Hautes Etudes, vol. xiii., No. 5 (1875); Ditto part ii., ibid, vol. xiv., No. 1 (1875): Notice sur le Genre *Caturus*, et plus particulièrement sur les Espèces du Lias supérieur de l'Yonne, Bull. Soc. Sci. Yonne, ser. 3, vol. vii., pp. 32-49, pls. i., ii. (1883); Note sur quelques Poissons du Lias supérieur de l'Yonne, ibid, ser. 4, vol. v., pp. 31-38, pls. i.-iii. (1891); Recherches sur les Poissons du Lias supérieur de l'Yonne, Zone à Ciment de Vassy, ibid, ser. 4, vol. vii., pp. 23-33, pls. i., ii. (1893); Note sur un Ganoide de genre nouveau du Lias de Vassy, Yonne, ibid, ser. 4, vol. viii., pp. 1-4, pl. i. (1894); Description de deux Espèces nouvelles de Poissons du Terrain Kimmèridgien du Cap de la Hève, Bull. Soc. Geol. Normandie, vol. xiv., pp. 26-30, pls. i., ii. (1892).

Type: Fishes; Whitby Museum.

The earliest reference to this small species of *Leptolepis* occurs in the first edition of Martin Simpson's "Fossils of the Yorkshire Lias" (p. 19), where it is stated to be "found in considerable numbers in the larger lenticular nodules, a little above the jet rock, in the Upper Lias. Contrary to what occurs in most of our fishes, the external covering has perished, and the head, fins, and bones only have been preserved. I am not aware," says Simpson, "to what particular genus it ought to be referred, but we may name it specifically—Saltviciensis."

The generic position of the fish was correctly determined in 1876 by Prof. J. F. Blake (*loc. cit.*), who published a figure and the following brief description:—

"The pectoral, ventral, and anal fins are about the same size, and are at equal distances apart. The dorsal is rather large, and is situated opposite the interval between the anal and ventral. The vertebral column is ossified, and the tail homocercal. The head is small and the teeth are comparatively large, and lie apparently in clumps. Length 4 in. by ¾ in."

In 1884, this description was merely quoted by Simpson in the second edition of his work; and the brief attempt at a diagnosis in the recently published Part III. of the British Museum Catalogue of Fossil Fishes is still insufficient for purposes of comparison. The fish seems to have been common, so that numerous specimens are available for study in the Yorkshire Museums and the British Museum; and the latter collection is so extensive that it is unnecessary to look elsewhere for fossils illustrating the essential characters of the species. Unfortunately, however, very few examples are complete and sufficiently undisturbed to show the general proportions of the fish. The two specimens represented of the natural size in pl. iii. figs. 1, 2, are thus almost unique.

The first of these fishes measures nearly 0·065m. in length, and the head with opercular apparatus occupies somewhat less than one-quarter of the whole. The form of the trunk is indicated by remains of the squamation; the width of the caudal pedicle being thus shown to equal half the maximum depth of the abdominal region, which is contained about six times in the total length of the fish. The head is too imperfect for detailed description, but the mandible distinctly projects in front of the upper jaw, the maxilla exhibits its characteristically arched form, and the position of the eye is marked by a black stain. The width of the opercular apparatus seems to have equalled half the length of the cranium. The vertebræ are imperfect and partly disturbed, so that they cannot be counted ; but two centra in the abdominal region are shown as smooth constricted cylinders. The few remains of delicate ribs prove that they terminated not far from the ventral border ; the slightly stouter but nevertheless delicate neural and hæmal arches in the caudal region are distinctly fused with their corresponding centra. The pectoral fin comprises not less than sixteen or eighteen delicate rays, of which the foremost is preserved for a length equalling two-thirds the maximum depth of the trunk. The pelvic fins arise much nearer to the anal than to the pectorals, and that of the right side shows at least eight rays, the foremost only a little inferior in length to that of the pectorals. The dorsal fin arises immediately behind the pelvic pair at a point nearly midway between the occiput and the caudal fin ; it is somewhat deeper than long, while the length of its foremost ray is about equal to the depth of the trunk at its insertion. The smaller anal fin arises opposite the hinder end of the dorsal fin. The caudal fin is deeply cleft, depressed in the fossil, and partly destroyed by a vein of spar which crosses it. There is nothing worthy of note in the squamation, unless some small streaks above the vertebral column, especially in the caudal region, denote a large canal for the "lateral line." The second specimen (fig. 2) is larger and more imperfect than the first, preserved in soft shale and with the mouth widely open. It is essentially similar in all features which can be compared, and shows the same longitudinal indents or streaks in the scales above the vertebral column both in the abdominal and caudal regions. The dorsal fin is very imperfect, the anal seems to be a little displaced backwards, and the caudal is almost completely destroyed. The stain on the shale produced by the remains of the scales and soft parts, is probably deeper than the original depth of the trunk, as suggested by the obvious displacement of the dorsal, anal, and pelvic fins.

Two distorted fishes associated on a small slab (pl. iii., fig. 3) are also interesting, the one as displaying the characteristic form of the dentary bone (*d*) with its ascending process, the other as showing more particularly the paired fins. The vertebral centra in these specimens are much deepened by crushing. The rays of the pectoral fins are not less than fifteen, and the rays of the pelvic fins at least ten in number.

Another specimen worthy of note in this connection is the small contorted fish shown in pl. iii., fig. 4. This is labelled by Agassiz, "*Leptolepis filipennis*, Ag., Street," and is marked by Egerton as intended to be the type specimen of the species thus merely named. No true *Leptolepis*, however, has hitherto been discovered in the Lower Lias, while the matrix of this specimen is identical with that of the fossil represented in fig. 1, even to the traversing veins of spar. The characters of the fish, so far as observable, are also identical with those of *L. saltviciensis*. The present writer thus feels justified in regarding it as a Whitby fossil, and in relegating *L. filipennis*, Ag., MS., to the synonymy of the species now under consideration. The head is very imperfect and a little elongated by crushing. The vertebræ are also fragmentary, but three of the simple constricted cylinders are seen immediately behind the pectoral fins, about as long as deep. The pelvic fins are further from these than from the anal. The specimen is a little weathered and tinged with vivianite.

A distorted fish (Brit. Mus., No. 41724) with well-preserved caudal vertebræ, shows that the centra in this region are longer than deep (pl. iii., fig. 5) ; and a general consideration of all known specimens indicates that the total number of vertebræ is about forty, half abdominal and half caudal. In short, summarizing the characters displayed by the numerous specimens available, it seems possible to formulate the following brief *diagnosis of the species* :—

A small, slender species with delicate skeleton, attaining a length of about 0·07m. Length of head with opercular apparatus greatly exceeding the maximum depth of the trunk, which is contained about six times in the total length of the fish ; caudal pedicle comparatively robust, its depth about half the maximum depth of the abdominal region. Vertebræ about 40 in number, half abdominal and half caudal; the centra delicate constricted cylinders longer than deep in the anterior part of the caudal region. Pelvic fins arising much nearer to the anal than to the pectorals; dorsal fin with length of foremost ray about equal to the depth of the trunk at its insertion, arising immediately behind the pelvic pair; anal somewhat smaller than the dorsal fin, and arising opposite the hinder end of the latter.

Family PHOLIDOPHORIDÆ.

PHOLIDOPHORUS GERMANICUS, Quenstedt.

PLATE IV., figs. 1-5.

1858.	*Pholidophorus germanicus,*	F. A. Quenstedt, Der Jura, p. 234, pl. xxx., figs. 9-11.
1891-95.	,, ,,	A. S. Woodward, Geol. Mag. [3], vol. viii., p. 545; and Catal. Foss. Fishes, B.M., pt. iii., p. 459.

Type: Nearly complete fish; Geological Museum, University of Tübingen, Würtemberg.

The occurrence of a large species of *Pholidophorus* in the Upper Lias of Whitby was first determined by the present writer in 1891. The only known specimens are preserved in the Egerton and Enniskillen Collections in the British Museum, and are proved on direct comparison to be specifically identical with *Pholidophorus germanicus,* described by Quenstedt from the Upper Lias of Würtemberg.

The only Whitby specimen showing the general proportions of the whole fish is very much fractured, with fragmentary and displaced squamation, and wanting the dorsal and anal fins (Brit. Mus., No. P. 4412). The head with opercular apparatus occupies about one-fifth of the total length of the fish, while another specimen (pl. iv., fig. 1) shows that its length is about equal to the maximum depth of the abdominal region. The width of the caudal pedicle must have about equalled one-third of this depth. The pelvic fins arise nearly midway between the pectorals and the caudal.

The specimen just mentioned merely shows that the maxilla was arched and that certain head-bones, notably those of the cranial roof, were ornamented with closely arranged, though coarse, rugæ. A second specimen (Brit. Mus., No. P.1058*a*) exhibits the head a little more satisfactorily (pl. iv., fig. 1). The cranial roof is exposed, crushed and fractured beyond recognition behind and in front, but displaying the large frontal bones (*fr.*), united in a wavy median suture, and a smaller plate on the right side, which may be either prefrontal or nasal (*na*). These bones are beautifully ornamented with closely vermiculating rugæ, not readily represented in a figure. The cheek-plates and jaws are too much crushed and confused for description; so also are the opercular bones, except the interoperculum and the lower end of the preoperculum. The former (*i. op.*) is triangular, somewhat deeper than broad; the latter (*p. op.*) is much expanded, and a fracture at its antero-inferior angle shows four of the radiating passages of the slime-canal filled with spar. The outer face of both these elements is nearly smooth and flat, but with traces of flattened tubercles in the lower portion. Two fragments of maxilla (*mx.*) indicate that this bone was externally ornamented behind with tubercles and short rugæ, anteriorly with longitudinal striæ. Behind the opercular apparatus the curved lower end of the robust clavicle (*cl.*) can be seen, and there is a pectoral fin consisting of robust, distally bifurcating rays. The scales are very imperfect, but those of the middle of the flank are obviously deeper than broad.

Delicate ring-vertebræ are observed in the abdominal region of one specimen (pl. iv., fig. 2), but nothing further is known of the endoskeleton of the trunk.

The left pectoral fin in the specimen which displays the ring-vertebræ seems to be complete except at the distal end, and exhibits eighteen stout rays. The pelvic fin, well preserved in No. P.4406 (pl. iv., fig. 3), has only eight similar rays, all closely divided and articulated in the distal portion. The proportions of the caudal fin, as indicated in the same specimen, are shown in pl. iv., fig. 4. The articulations are distant in the proximal half of the rays of the lower lobe, and four of the small fulcra are preserved on the anterior margin of this lobe.

The arrangement of the fins is shown in the imperfect specimen represented in pl. iv., fig. 5. A fragment of the dorsal fin (*d.*) is opposed to remains of the pelvic pair (*plv.*); and the anal fin (*a.*) seems to have arisen midway between the latter and the caudal (*c.*).

The last-mentioned specimen also affords the best view of the squamation. Some of the scales of the flank are deeper than broad, even in the hinder half of the caudal region ; and when their posterior border is preserved, it seems to be gently convex without any trace of serrations. The feeble rugose ornament, characteristic of the species, is scarcely perceptible except on the hinder two-thirds of the caudal region ; and even here the direction of the light must be carefully adjusted before it can be distinctly observed. The rugæ are most conspicuous on the anterior half of the scale ; they are rounded, sometimes more or less blended or branching, and there is often a distinct tendency to their passing into fimbriations at the superior and anterior borders. A few of the scales of the "lateral line" exhibit a deeply-oval foramen for the passage of the sensory canal.

In addition to the Whitby fossils thus described, the collection of the British Museum comprises numerous typical examples of *Pholidophorus germanicus* from the Upper Lias of Würtemberg. As already mentioned, it is thus possible to determine the species from the Whitby Lias by the direct comparison of specimens ; and some of the features, not very clearly shown in the fossils now under consideration, can be well observed in examples from the typical locality. Summarizing all these essential characters, the following *diagnosis of the species* may be appended :—

A large species, attaining a length of about 0·3m. Length of head with opercular apparatus somewhat exceeding the maximum depth of the trunk, which equals about one-fifth of the total length of the fish. The rugose ornament of the head and opercular bones very fine, but conspicuous ; maxilla and dentary longitudinally striated. Pelvic fins arising slightly in advance of the middle point of the trunk, with the dorsal fin directly opposed. Scales large and nearly smooth, but with a faint, coarse rugosity, most conspicuous in the caudal region ; their hinder margin very slightly convex and not serrated ; at least six longitudinal flank-series much deeper than broad.

Family EUGNATHIDÆ.

EUGNATHUS FASCICULATUS, Agassiz, MS.

PLATE III., figs. 6, 7.

1844. *Eugnathus fasciculatus*, L. Agassiz, Poiss. Foss. vol. ii., pt. ii., p. 105 (name only).

Type : Specifically indeterminable remains ; British Museum.

The genus *Eugnathus* has already been recorded from the Whitby Lias by Agassiz, but he gives no information as to the nature of the specimens. *Eugnathus fasciculatus* is merely mentioned as a Whitby species, to be described in a forthcoming supplement, which unfortunately never appeared.

This record is based on two specimens in the collections of the late Sir Philip Egerton and the late Earl of Enniskillen, now in the British Museum, both bearing the specific name "*fasciculatus*," written by Agassiz himself on the label. Both the fossils, however, are much too imperfect for specific determination ; and as no better examples appear to have been hitherto discovered, it must suffice to describe them merely under the name they bear, without attempting any specific diagnosis.

The first specimen in the Egerton collection (Brit. Mus., No. P.508) is marked as the type, and probably represents a fish not less than 0·35m. or 0·4m. in length ; but only part of the squamation is preserved with other indeterminable fragments on a much-broken slab of shale. The scales seem to belong to the middle region of the trunk, none deeper than broad, but nearly all considerably broader than deep. When well preserved the exposed portion of each scale is shown to be ornamented with the radiating ridges and pectinations characteristic of the genus ; and all the ridges are very sharp, as shown in the three scales represented in pl. iii., fig. 7. The dorsal and ventral scales are, as usual, excessively broad in proportion to their depth.

The second specimen labelled by Agassiz cannot have attained a greater length than 0·15m., and is preserved in counterpart, one side having been obtained from the Enniskillen collection (Brit. Mus., No. P.4468), the other from the Egerton collection (Brit. Mus., No. P.873). The scales are much less conspicuously ornamented than in the previous specimen, though this difference may be due to immaturity or even to the state of preservation.

The best side of this small fossil is shown of the natural size in pl. iii., fig. 6. The head is almost entirely wanting, and the abdominal region is evidently a little deepened by distortion. The width of the caudal pedicle would originally much exceed one-third of the maximum depth of the trunk, and the latter measure would be slightly greater than one-third of the length from the pectoral arch to the base of the caudal fin. Nothing is seen of the axial skeleton of the trunk, although circumstances seem favourable to its exposure if it happened to be ossified. Portions of all the fins are exposed, except the pelvic pair, and they consist of stout rays finely subdivided and closely articulated distally. Each fin is also shown to be provided with an anterior fringe of large, slender fulcra. The pectoral fin (*pct.*) is relatively large, with about fifteen rays which are undivided in their proximal half. The dorsal fin (*d.*) is crushed, but apparently as deep as long, with not less than ten or twelve rays, and arising opposite a point midway between the pectoral and anal fins. The anal (*a.*) is only about half as large as the dorsal. Of the caudal fin (*c.*) nothing beyond the base is preserved ; but some of the inferior rays are enamelled and exhibit joints longer than broad. The scales are preserved in patches on both sides of the fossil. They are all finely serrated on the hinder border as far as the posterior half of the caudal region, when they become entirely smooth, with a slightly concave outer face. Even the scales on the anterior part of the abdominal region are almost destitute of pectinations, none showing more than traces of the concentric lines of growth and a few punctate markings. The scales of the middle of the flank in the abdominal region are very imperfect, but appear to be about as broad as deep. A few of the displaced scales at the ventral border are excessively broad compared with their depth. Dorsally and on the caudal region, all the scales are longer than deep ; and there is evidence that the ridge-scales even at the base of the upper caudal lobe are not much enlarged. There are traces of the peg-and-socket articulation in impressions of some of the scales just in advance of the dorsal fin ; and the caudal scales exposed from within exhibit the characteristic median vertical ridge. Each scale of the series of the "lateral line" is pierced by a foramen with partially raised rim.

SPECIFICALLY INDETERMINABLE REMAINS OF EUGNATHUS OR HETEROLEPIDOTUS.

1844. *Lepidotus rugosus,* L. Agassiz, Poiss. Foss., vol. ii., pt. i., p. 246 (in part), pl. xxxiii *a*., fig. 4 (*non* figs. 1, 3, 5, 8).

1844. *Aspidorhynchus anglicus,* L. Agassiz, *ibid.*, p. 139 (name only).

1843-52. *Lepidotus pectinatus,* P. M. G. Egerton, Proc. Geol. Soc., vol. iv., p. 183, and Figs. and Descript. Brit. Organic Remains, dec. vi. (Mem. Geol. Surv., 1852), no. 3, pl. iii.

The name of *Lepidotus rugosus* is given by Agassiz to miscellaneous fragmentary remains which will be discussed later, but which comprise one portion of squamation from the Upper Lias of Whitby almost certainly referable either to *Eugnathus* or to the nearly identical genus *Heterolepidotus.* This specimen is now in the British Museum, and on comparison the scales are observed to be much more closely similar to those of the typical *Heterolepidotus* from Lyme Regis than to those of *Lepidotus.* They are more delicate than the scales usually are in the latter genus ; but it is unfortunate that the overlapped margin cannot be distinctly seen, to determine whether or not the anterior angles are produced forwards.

Careful examination and comparison of the imperfect jaw from the Upper Lias of Whitby, named *Aspidorhynchus anglicus* by Agassiz (Brit. Mus., No. P.450), indicates that this fossil must also be referred either to *Eugnathus* or *Heterolepidotus.* It is a much-abraded ramus of the mandible, with remains of the conical teeth, and a figure of the specimen is given in the Catal. Foss. Fishes, Brit. Mus., part iii. (1895), pl. viii., fig. 2.

The imperfect fish described by Egerton under the name of *Lepidotus pectinatus,* is too unsatisfactory both for generic and specific determination ; but this also very probably represents an unknown large species of *Eugnathus* or *Heterolepidotus.* The pectination of the scales is confined to the abdominal region, where it is a little emphasized by the abrasion of the outer surface. Beyond the origin of the dorsal fin all the scales are smooth and with non-serrated hinder border; while those of some series at the ventral border are excessively broad compared with their depth. None of the head-bones or opercular plates can be distinguished.

Ptycholepis bollensis, Agassiz.

Plate V.

1832. *Ptycholepis bollensis,* L. Agassiz, Neues Jahrb., p. 142 (name only).
1833-44. ,, ,, L. Agassiz, Poiss. Foss., vol. ii., pt. i., p. 11; pt. ii., p. 108, pl. lviii. *b*.
1849. ,, ,, W. C. Williamson, Phil. Trans., 1849, p. 444.
1852. ,, ,, F. A. Quenstedt, Handb. Petrefakt., p. 203, pl. xv., fig. 5.
1858. ,, ,, F. A. Quenstedt, Der Jura, p. 231, pl. xxx., figs. 1-7, pl. xxxi., fig. 8.
1865. ,, ,, G. Cotteau, Bull. Soc. Sci. Yonne, vol. xix., pt. ii., p. 337.
1875. *Ptycholepis barrati,* H. E. Sauvage, Bibl. Ecole Hautes Etudes, vol. xiv., No. 1, p. 8, pl. ii., fig. 2. [Distorted fish.]
1891. ,, ,, H. E. Sauvage, Bull. Soc. Sci. Yonne, vol. xlv., pt. ii., p. 33, pl. i.
1895. *Ptycholepis bollensis,* A. S. Woodward, Catal. Foss. Fishes, B. M., pt. iii., p. 317.

Type: Imperfectly preserved fish from Whitby; British Museum.

The definition of the genus *Ptycholepis*, published by Agassiz, was based upon an imperfect fish from the Whitby Lias, now in the British Museum. Though the typical species, *P. bollensis*, to which the Whitby fish belongs, was originally named after Boll, the locality in Würtemberg where the first fragments were met with, this was the only satisfactory example which Agassiz had the opportunity of examining. Even this specimen, however, is so imperfect as to be misleading in some respects, and fossils subsequently discovered both at Whitby and in Würtemberg reveal certain errors in the original interpretation by Agassiz.

The type specimen of *Ptycholepis bollensis* thus needs a new description in the light of present knowledge. It is much shattered and fractured, but displays the head from the ventro-lateral aspect, the greater portion of the trunk, the paired fins, and the base of the caudal fin. The remains of the cranial and facial bones are ornamented with coarse but closely arranged rounded ridges, which are mostly directed longitudinally ; and the same ornament is continued over the operculum and suboperculum, so far as preserved. The jaws are too imperfect for description ; but between the rami of the mandible there are fragments of very broad branchiostegal rays, and, apparently, a gular plate, all these destitute of external ornamentation. There is also a narrow smooth plate, with partly fimbriated hinder margin, immediately behind the opercular bones. Nothing is seen of the internal bones of the trunk, for the squamation is thick, and, although it is much disturbed, it still completely covers the skeleton. The pectoral fins are apparently crushed together and consist of stout rays, which are only articulated and divided towards the distal end ; the foremost ray bears traces of small fulcra. The right pelvic fin (described by Agassiz as "anal") is smaller though similar. None of the rays exhibit any ornamentation. The median fins are all lost, except a small part of the base of the caudal. The trunk is crushed in the same direction as the head, and the very narrow ventral scales thus predominate. These are excessively narrowed and marked by two or three of the characteristic rounded longitudinal ridges. Even the scales, which evidently belong to the middle of the flank, are longer than deep, and several of these are displaced, exhibiting the broad and smooth overlapped area. All of the latter are highly ornamented with the longitudinal ridges, which abruptly terminate at the anterior margin, but usually become fused together behind, while the posterior margin of the scale is coarsely serrated. In fact it may, perhaps, be more correct to describe the scales as longitudinally furrowed, the delicate furrows extending to the anterior, but not to the posterior margin. The only specially modified scales are observed on the ventral median line, one between the pelvic fins, the other immediately in advance probably of the origin of the anal fin. Each of these scales is elongate-oval in form, narrower behind than in front, equalling two ordinary scales in length, and externally ornamented with longitudinal ridges, which converge a little at either end.

A second specimen shown of the natural size in pl. v. fig. 1, is of more importance for determining the specific characters of the fish, not being distorted ; but this example unfortunately wants the dorsal part of the caudal region. The length of the head with opercular apparatus is shown to be approximately equal to the maximum depth of the abdominal region, and would occupy somewhat less than one quarter of the total length of the fish. The cranium is partly crushed downwards, and exposed from above ; but its lateral margin is apparently entire, and the large excavation for the orbit (*orb.*) is conspicuous. The cheek-plates are removed, thus exposing some obscure remains of the pterygo-quadrate arcade ; but the maxilla (*mx.*) is nearly complete, deepest behind, and marked with coarse rugæ which are mainly longitudinal. The mandible (*md.*) is imperfect, ornamented with two or three longitudinal rugæ near its inferior border, and with upwardly turned rugæ above. The operculum (*op.*) wants a little of its outer surface below, and is fractured by a vertical crack behind ; but its maximum depth is evidently a little greater than its width, and the ornamented ridges on its outer face are mostly short, with a distinct trend postero-inferiorly. The other opercular plates and the branchiostegal rays are too imperfect for description ; while the characters of the clavicle (*cl.*) immediately behind are also obscure. The pectoral fin (*pct.*) exhibits remains of not less than fourteen stout rays more or less subdivided distally ; and one of the pelvic fins (*plv.*), with at least ten rays which are distantly articulated in the terminal half, arises very slightly nearer to the pectorals than to the caudal fin. The anal fin is wanting, and there are only insignificant fragments of the dorsal (*d.*) and caudal (*c.*), the former well in advance of the pelvic pair. The fin-rays of the lower caudal lobe are distantly articulated almost from the base, and very finely divided distally. The scales are scarcely disturbed except where the fish is imperfect, and all are much broader than deep. The extent and direction of the small longitudinal furrows separating the ornamental ridges on the various scales differ a good deal, as shown in the enlarged outline-drawing (fig. 1*a*) ; but they are most numerous at the anterior border of the scale, and most frequently reach the hinder border of the scales of the foremost rows, where the direction is comparatively oblique. The narrowed ventral scales exhibit only two or three longitudinal ridges, while the deepest flank-scales have perhaps eight, in part fused together. The enlarged scales in the pelvic and anal regions are not shown ; but the arrangement of the diminutive scales at the base of the lower caudal lobe is interesting. The latter (shown enlarged in fig. 1*b*) are quite smooth, while those of the marginal row bordering the fin-rays are club-shaped, excessively elongated in the direction of these rays and pointed at the end. The "lateral line," as usual, is shown to be remarkably low on the flank, the course of the sensory canal being marked by large vertical clefts near the hinder end of a few scales of the series it traverses.

Some further information as to the characters of the head may be obtained from two other specimens in the British Museum, numbered P.858 *a* and 35581. The first (pl. v., fig. 2) exhibits the longitudinal ridges on the maxilla (*mx.*) and the upturned ridges on the mandible (*md.*) ; while the ornament on the operculum (*op.*) and a fragment of the suboperculum (*s.op.*) is remarkably well shown. The two or three uppermost ridges on the operculum are horizontal ; then some short ridges are intercalated behind, and those below trend downwards but are less subdivided than in the original of fig. 1. The ridges on the suboperculum are chiefly horizontal, and the true form of this bone is indicated by an impression in No. 35581, which enables us to add the sharp outlines to our figure. Below the suboperculum and mandible there are obscure remains of the smooth branchiostegal rays and gular plate (*gu.*), which are only finely punctate. An impression of one of the ceratohyal bones in a third specimen (fig. **3**, *ch.*) presents no noteworthy feature.

The last specimen is the ventral aspect of a small fish exposed in a nodule (Brit. Mus., No. P.5222), and is especially interesting as exhibiting the paired fins and squamation. The pectoral fin on the left side (*pct.*) has at least twenty-two stout rays, with finer rays behind, distantly articulated nearly to the base and most shown to be divided distally ; its anterior border is fringed with minute fulcra. The pelvic fin on the left side (*plv.*) is similar but smaller, with only about sixteen rays. The series of scales seem to correspond with the myocommata of the trunk, but they are modified between the bases of the fins ; whereas the angle the series make in the median line points backwards as a rule, the direction suddenly changes between the pectoral fins. Moreover, the short basal lobe of the pectoral fin is shown to be invested on its inner face with comparatively small scales (*b.*) ; while bordering this lobe within is a longitudinal series of slightly enlarged scales (*x.*), all apparently about as broad as long. Between the pelvic fins there are also at least two enlarged scales (*p.x.*), but they are somewhat fractured and their outline is not quite clear.

Another fragment (Brit. Mus., No. 35580) exhibits the dorsal fin consisting of more than twenty stout rays, some of the basal joints with traces of an ornament of longitudinal ridges.

The *specific characters* of the Whitby *Ptycholepis* may thus be enumerated as follows :—

The type species, attaining a length of about 0·35 m. Length of head with opercular apparatus equalling the maximum depth of the trunk and nearly one-quarter of the total length of the fish. The ridged ornament of the head coarse, very rarely mingled with few tubercles, and covering all the external bones except the gular plate and branchiostegal rays, which are nearly smooth ; the supraclavicle also ornamented with finer transverse ridges. Most of the ridges on the cranium, cheeks, and opercular bones longitudinal ; the ridges on the upper portion of the dentary and hinder half of maxilla oblique. The stouter fin-rays ornamented with few fine longitudinal ridges of ganoine ; pelvic fins arising midway between the pectorals and the caudal ; dorsal fin with slightly more than twenty rays, arising well in advance of the pelvic pair. Scales marked with from one to four or five delicate, irregular, longitudinal furrows, sometimes discontinuous, sometimes branching, rarely reaching the hinder border except on the middle of the abdominal flank, and producing an ornament of large, incomplete, rounded ridges ; the hinder border deeply and coarsely denticulated.

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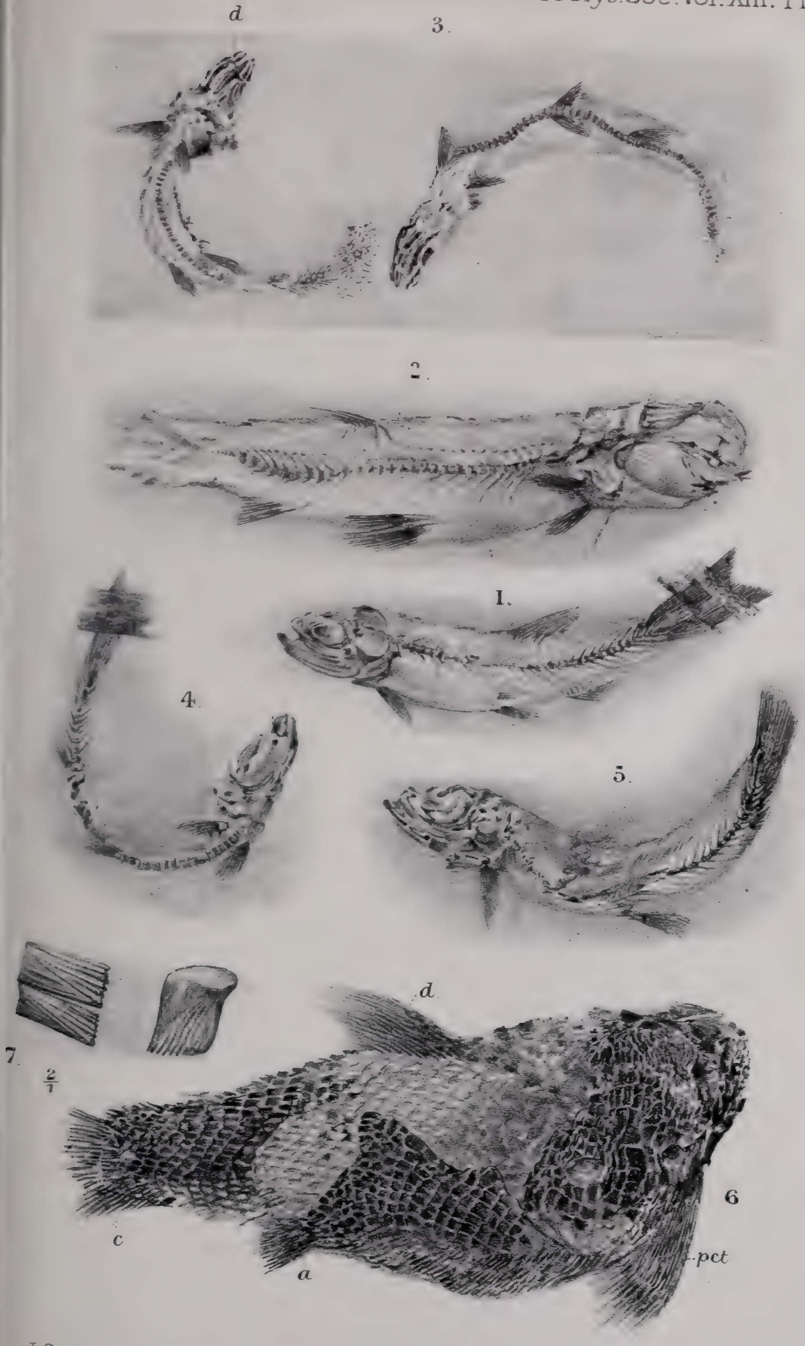
NOTE.—All the specimens represented on these plates are preserved in the British Museum, and the numbers in square brackets refer to the Register of the Department of Geology. Unless otherwise stated, the figures are of the natural size.



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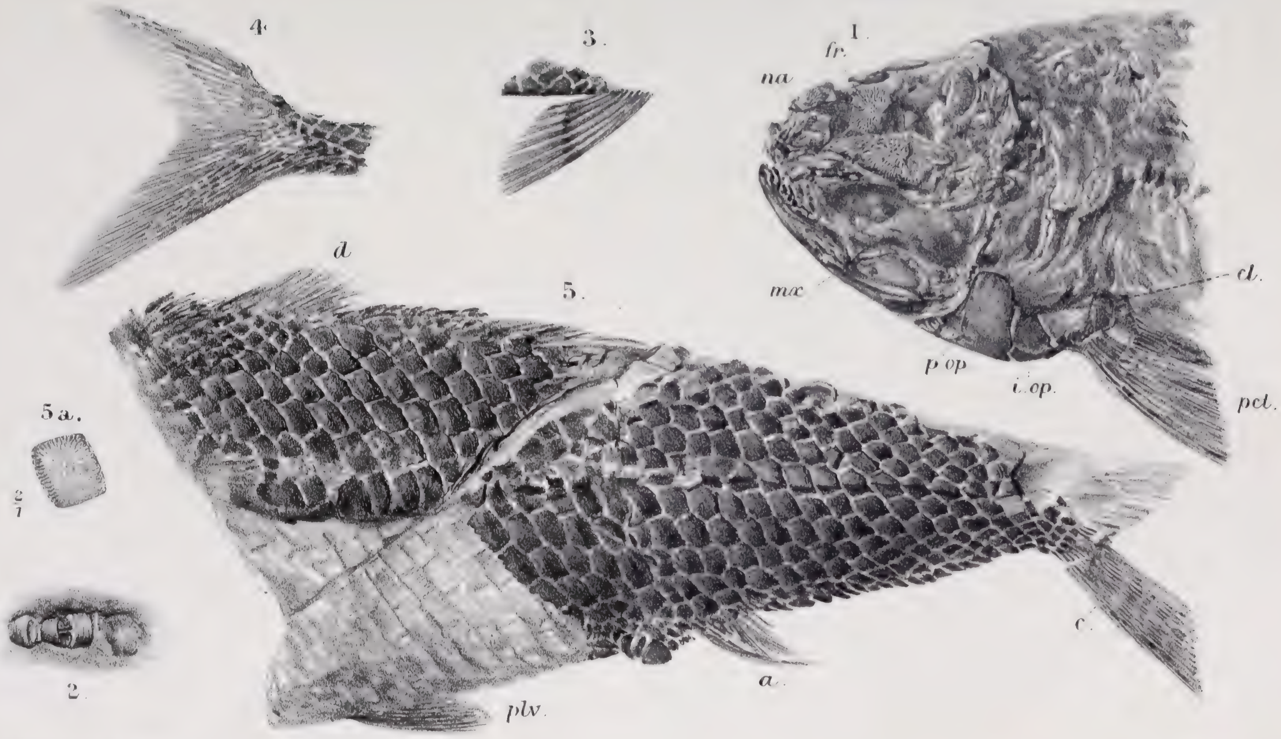
1–5. LEPTOLEPIS SALTVICIENSIS.
6, 7. EUGNATHUS FASCICULATUS.



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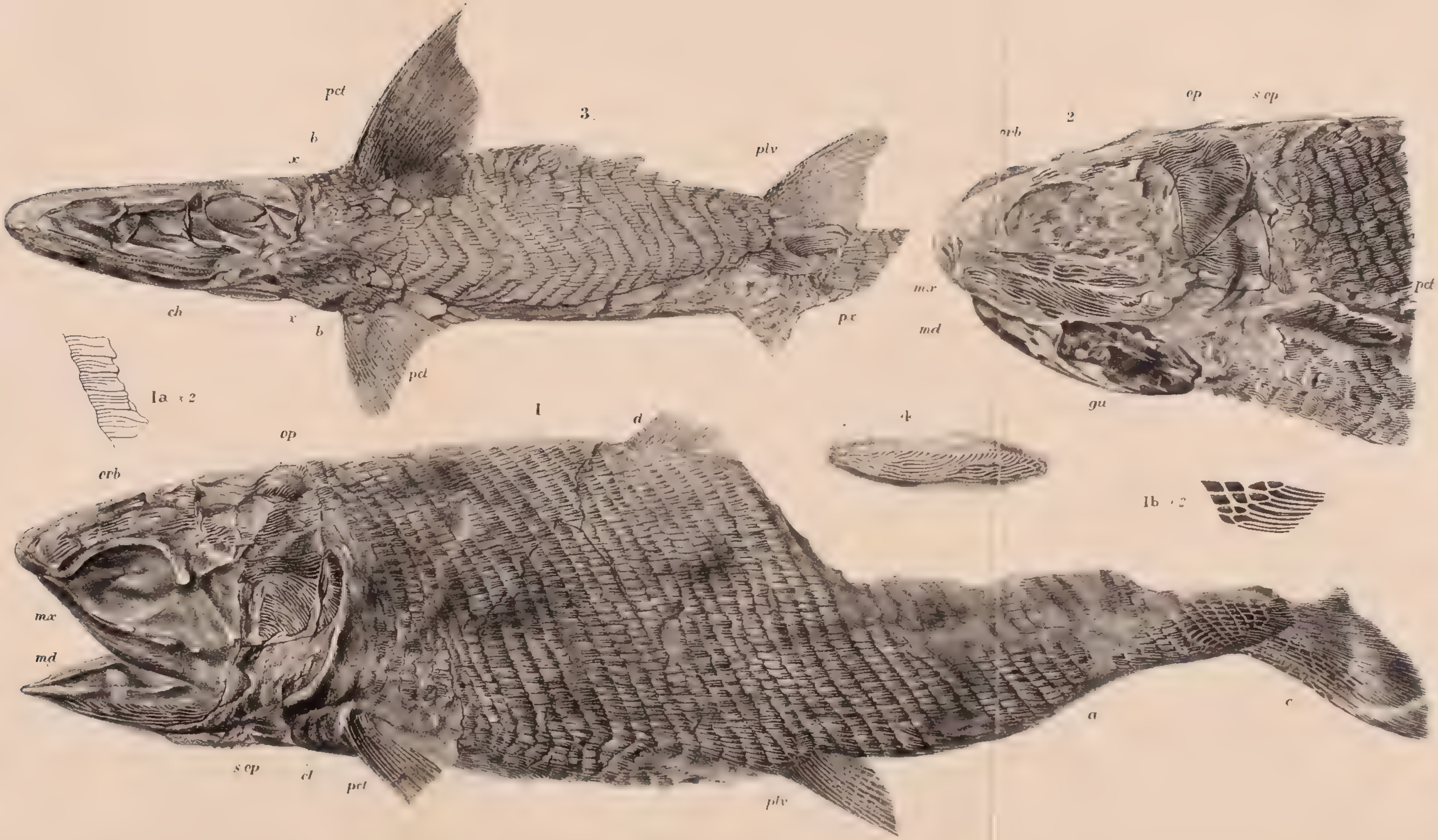
PHOLIDOPHORUS GERMANICUS.



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PTYCHOLEPIS BOLLENSIS.

ON SOME RECENT ADVANCES IN BRITISH PALÆOBOTANY.

BY THOS. HICK, B.A., B.SC., A.L.S.

Assistant Lecturer in Botany, Owens College, Manchester.

(Received and Read November 13th, 1895.)

In a paper read before this Society in 1891,[*] I referred to the advantage of periodically taking stock of our possessions in matters of science, and gave an outline of what was then known of the structure of the Yorkshire specimens of *Calamites.* On the present occasion I propose to repeat the process on a somewhat more extensive scale, and to give a summary account of some of the most notable additions which have been made to our knowledge of certain types of Carboniferous plants, since the former paper was written. I will begin with the genus *Calamites.*

CALAMITES.

Our knowledge of the organisation and structure of the plants referred to this genus has been so greatly extended during the last four years, that they may now be regarded as among the best known of the plants of the Coal Measures. To show this, it will be convenient, as in the previous paper, to take the different members of the plant in the usual order, and point out in each case the nature of the discoveries which have been made with respect to it.

The Roots.—With reference to the roots of *Calamites,* I stated in 1891[†] that our knowledge of their structure, so far as our Yorkshire specimens were concerned, appeared to be a complete blank. It was noted, however, that M. Renault's researches had led him to the conclusion that the fossils known as *Astromyelon* were in reality the roots of *Calamodendron* and *Arthropitys,* which are forms of *Calamites.* But seeing that in the Yorkshire forms of *Astromyelon,* the chief characteristics of a root structure had not been made out, I deferred accepting this determination until evidence of their possessing such a structure was forthcoming.

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[*] Proc. of the Yorksh. Geol. and Polyt. Soc., vol. xii., pt. i., 1891.

[†] Loc. cit., page 3.

Since then M. Renault has published the results of further investigations on the subject,* which fully establish the correctness of his views, so far as they affect the French fossils which he refers to the genus *Astromyelon*.

This led to a re-investigation of the English specimens of *Astromyelon* by the late Prof. Williamson and Dr. D. H. Scott, who communicated a memoir to the Royal Society in October of last year, specially devoted to the roots of *Calamites*. At the time of writing, the memoir has not been published *in extenso* with the usual illustrations, but an abstract of it will be found in the Proceedings.† In this the authors express the opinion that Renault's views of the nature of *Astromyelon* may be safely extended to our English fossils. They found specimens of *Astromyelon* arising as adventitious roots from the stem of *Calamites*, and having all the characteristics of normal roots, including centripetally developed primary xylem strands, alternating in the primary stage with phloem strands, and at a later period with the secondary xylem bundles.

It seems then that the evidence asked for in 1891 as to the root-nature of *Astromyelon* is now supplied, and that the blank in our knowledge of the structure of the roots of *Calamites* has been satisfactorily filled up.

In saying this, however, it must be added that, so far, my own observations have not confirmed this view of the nature of *Astromyelon*. I have carefully examined a large number of preparations of the fossil, some of them in a state of preservation which is practically perfect, so far as the critical tissues are concerned, and have failed to distinguish the centripetally developed primary xylem strands, from the secondary xylem bundles. Under these circumstances it will be for further investigation to show whether two distinct plants, or parts of plants, have hitherto been confused under the name of *Astromyelon*, or whether there is some other explanation of the apparent discrepancy.

The Stem.—In 1891, the structure of the aerial stems of *Calamites* was said to be tolerably well known, at least in a general way, but it was intimated that additional information was being accumulated.* Since then, the late Prof. Williamson and Dr. D. H. Scott have re-investigated the matter, and have published their observations in a joint memoir contributed to the Philosophical Transactions for 1893. These observations deal with numerous questions of anatomy and development, which previous researches had left unanswered, and bring our knowledge of these stems much nearer the level of that of recent plants than had been possible before. In the main, however, they refer to the stem of *Calamites* after the secondary changes it usually exhibits had made some advance, and the primary condition is not so fully dealt with.

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* Flore fossile d'Autun, etc., pt. ii., 1893.

† Proceedings of the Royal Society, vol. lvii., 1894.

Last year I was able, in some measure, to make up for this by publishing a series of fresh observations specially bearing upon the primary structure of the Calamitean stem,† as found in a type of *Calamites* which is very common in the Lower Coal Measures of Yorkshire. Without going into details, for which the paper itself must be consulted, it may be submitted that those who will read it along with the much more elaborate memoir by Williamson and Scott, will admit, that from a very early to a somewhat late stage of development, the stem of *Calamites* is quite as well known as those of the majority of recent plants. It is not certain that all the stems dealt with by Williamson and Scott are of the same species as those described in my paper, but in spite of this, the one set may be regarded as complementary to the other, until we are able to distinguish individual from specific differences. All the same it may be worth mentioning that my specimens are of the type known as *Arthropitys*, which seems to be the one that is most abundant in the Lower Coal Measures of Yorkshire. A notable feature in them is the peculiar character of the inner cortex, which consists of relatively large cells, but of different sizes, containing masses of black carbonaceous matter. These cells form a continuous zone of tissue which I have elsewhere named "melasmatic" tissue.

The Leaves.—As in the case of the roots, so in that of the leaves of *Calamites,* it was necessary to admit in 1891 that little or nothing was known of their structure.* But no such necessity exists now. In working out the primary structure of the stem, my attention was frequently arrested by sections of leaves which, from certain well-marked histological characters, I concluded were the leaves of the Calamitean stems associated with them. Subsequently demonstrative proof of this conclusion was obtained from preparations made by Mr. Binns, of Halifax, and in April of this year a detailed description of these leaves was communicated to the Manchester Literary and Philosophical Society.† So far as I can discover, this is the first and only account hitherto published of the structure of the leaves of *Calamites*, and this being so, a brief description of the chief features may not be unacceptable here, though full details must be sought in the paper referred to.

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* Loc. cit., page 4.

† Mem. and Proc. of the Manch. Lit. and Phil. Soc., series 4, vol. viii., 1893-4.

Arranged in whorls at the nodes of the ultimate twigs, the leaves of the *Arthropitys* type of *Calamites* are small, linear structures, measuring approximatively $2\frac{1}{2}$ millimetres ($\frac{1}{10}$ inch) in length, $\frac{2}{3}$ millimetre ($\frac{2}{75}$ inch) in breadth, and $\frac{5}{12}$ millimetre ($\frac{1}{60}$ inch) in thickness. In transverse sections near the middle, the shape is not unlike that of the leaves of some Conifers, the upper surface being somewhat flattened, the lower more or less convex, and the margins extended into narrow blunt wings. At the outside of the section is an epidermis composed of a single layer of cells. Beneath this is a layer of palisade cells, continuous, or nearly so, all round the section, and forming a zone of assimilating tissue, which widens out at the side to form the obtuse wings. The central part of the leaf enclosed by the assimilating tissue is circular in section. Externally it carries a single layer of large cells, with black contents, forming a "melasmatic" tissue, which is either continuous round the section or interrupted at the middle point of the upper side. Within the "melasmatic layer" we have a circular group of apparently cellular elements, in which is placed, excentrically and nearer the lower side, the transverse section of a very delicate vascular strand.

Towards the base and apex of the leaf the transverse sections show a number of minor modifications in shape and structure, but in most cases the organisation is radial rather than dorsiventral, and we can usually recognise—

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* Loc. cit., p. 5.

† Mem. and Proc. of the Manch. Lit. and Phil. Soc., series 4, vol. ix., 1894-5.

1. A central cylinder or stele, in which is a delicate, eccentric, vascular strand,
2. A zone surrounding this, corresponding to the cortex of the stem, and made up of
   (*a*) An inner single layer of "melasmatic" elements, and
   (*b*) An outer thicker layer of assimilating tissue.
3. A single layered epidermis.

The presence of a "melasmatic" layer in these leaves, corresponding in its histological characters and position with that of the stem, is an indication that they belong to the same type of *Calamites* as the stems referred to.

The Fruits.—In referring to the fruits of *Calamites* in 1891, I summarised very briefly the conflicting views held by palæobotanists with respect to the sporangiferous spike known as *Calamostachys Binneyana* Schimp., views which had already been set forth at full length by Mr. Cash.* Reference was made to the fact that in the first part of the General, Morphological, and Histological Index† to his Memoirs, Williamson modified the views he had previously expressed at various times so far as to include the spike in the great group of *Calamarieæ*, but it was pointed out that this was not the same thing as affirming that it was the fruit of *Calamites.* Moreover, in so placing it he did not associate it with the genus *Calamites,* but with the fossils which he then named *Asterophyllites,* but which he subsequently referred to the genus *Sphenophyllum.*‡ The discrepant views as to the affinities of this spike were attributed to the absence of any published specimen which showed, in a demonstrative manner, the structure of the axis, and the suspicion was expressed that that axis would yet prove to have a Calamitean structure, and that in some cases at least this "fruit" would turn out to be that of *Arthropitys.*

This suspicion was almost immediately converted into a certainty.

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* Proc. of the Yorksh. Geol. and Polyt. Soc., 1887, pp. 444 et seq.

† Mem. and Proc. of the Manch. Lit. and Phil. Soc., ser. 4, vol. iv., 1890-91.

‡ Williamson and Scott, Phil. Trans., vol. clxxxv., B. (1894).

Early in the following year (1892) a number of fine sections of the spike, prepared by Mr. James Binns, of Halifax, were generously placed in my hands by my friend Mr. Cash, and were subjected to careful examination. It was soon found that they afforded all the evidence we required to prove that, as a matter of fact, the axis of *Calamostachys Binneyana* Schimp, has, in all essential points, the same structure as the stem of *Calamites.* This being so, it was at once clear, that the affinities of the spike were with *Calamites* and not with the other types to which it had been previously referred. Thanks to the excellence of the preparations, it was even possible to go a step further and to indicate, on the ground of certain anatomical peculiarities, the type of stem which had borne it as its fruit. Among these peculiarities is the presence of a "melasmatic" layer of tissue in the sterile bracts of the spike. These bracts have a structure which is obviously but a modification of that of the leaves, and the "melasmatic" layer agrees in all respects with that already noticed in the leaves and stems. On this and other grounds, there is no doubt, in my own mind, that these leaves and stems already referred to, and *Calamostachys Binneyana,* are all parts of one and the same type of *Calamites,* which appears to be that known as *Arthropitys.*

A paper containing the results of the observations made was read at the Edinburgh Meeting of the British Association in 1892,* at the Geological Society of London in the same year, and before this Society in March, 1893. Subsequently it was published in the Proceedings,† where those interested may be referred for details.

At the end of 1893, an elaborate memoir on *Calamites, Calamostachys* and *Sphenophyllum,* was communicated to the Royal Society by the late Prof. Williamson and Dr. D. H. Scott, in which the structure of *Calamostachys Binneyana* Schimp. was described in detail, and its affinities discussed at considerable length.‡ In the result, they seem to have arrived at substantially the same conclusions on both matters as I had previously reached, so that it may now be said that the Calamitean affinities of the spike are generally acknowledged.

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* Report 1892, p. 776.

† Proc. of the Yorksh. Geol. and Polyt. Soc., vol. xii., 1894.

‡ Phil. Trans., vol. clxxxv., B. (1893).

In addition to *Calamostachys*, there is another type of spike which from its structure Williamson long ago described as the "true fruit of *Calamites*,"* and which he and Scott have further investigated in the memoir referred to. They are so convinced of the Calamitean nature of this spike that they distinguish it as *Calamites pedunculatus*, but they point out that it bears a close resemblance to the strobilus described by Renault under the name of *Volkmannia gracilis*,† and placed by Solms-Laubach in Weiss's genus *Palæostachya*.‡

Discussing the question as to whether or not the two types of spike have belonged to closely allied plants, they appear to favour the view that they have, a view which in the present state of our knowledge appears to be the most probable one. Personally I am the more inclined to accept it because my own observations have led me to the conclusion, that as at present constituted, the genus *Calamites* is a collective one, and includes several forms that may ultimately be separated as distinct genera, In that case, it may well be that different sections of the group may have had somewhat different fruit-spikes.

SPHENOPHYLLUM.

It has been mentioned above that the fossils, originally described by Williamson under the name of *Asterophyllites*,‖ were subsequently transferred by him to the genus *Sphenophyllum*.§ This is an important change, as it gives the fossils a more definite place among Carboniferous Cryptogams, and removes the source of some confusion, continental palæobotanists usually giving the name *Asterophyllites* to leafy branches of *Calamites* or of Calamitean affinities.

A still more important matter in connection with this genus is the discovery recently made by M. Zeiller with respect to its fruit. So far back as 1871 Williamson described a fossil fruit-spike under the name of *Volkmannia Dawsoni*,* which differed materially from all the spikes previously known. Subsequently he made further investigations into its structure, which were published in the Philosophical Transactions for 1874, 1890, and 1891. But in 1884 Weiss had transferred the spike to the genus *Bowmanites*,† established in 1870 by Binney for a spike which he named *Bowmanites cambrensis*,‡ and Williamson adopting this change, the spike became known as *Bowmanites Dawsoni.* Like that of *Volkmannia Dawsoni*, however, this name proved to be a provisional one only, for M. Zeiller in studying some fine preparations of the fruit of *Sphenophyllum cuneifolium*, came to the conclusion that *Bowmanites Dawsoni* was the fruit of that species of *Sphenophyllum.* In a short paper contributed to the *Comptes rendus de l'Academie des Sciences* in 1892, he gives the reason for this conclusion, and states that the spikes of *Sphenophyllum cuneifolium* were, in every respect, identical in structure, as well as in the size of the various parts, with the spike described by Williamson. In 1893 he published a full account of his observations with illustrations,‖ which, according to Williamson and Scott,§ leave no doubt as to the essential agreement between the undoubted strobili of *Sphenophyllum* which he investigated, and the English specimens described as *Bowmanites Dawsoni.* The question as to specific identity, however, they prefer for the present to leave an open one.

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* Phil. Trans., 1888.

† Annales des Sciences Naturelles, Botanique, series 4, tome iii.

‡ Fossil Botany, p. 332.

‖ Phil. Trans., 1874, 1878.

§ General, Morphological and Histological Index, part ii.

Here then we have another fruit-spike brought into its proper relations with the plants to which it belongs, and it becomes possible to describe with some fulness both the stems and the reproductive organs of *Sphenophyllum.* We are still somewhat in the dark however as to the roots, and our knowledge of the structure of the leaves is not complete, but it is scarcely too much to hope that before long these deficiencies may be made good.

As regards the structure and development of the stem of *Sphenophyllum* and the differences met with in the species whose structure is known, our knowledge has been greatly extended by the recent investigations of Williamson and Scott. The details of these are contained in the memoir referred to already, and a study of them will show how much they are in advance of the knowledge previously acquired.

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* Mem. and Proc. of the Manch. Lit. and Phil. Soc., ser. 3, vol. iv.

† Steinkohlen-Calamarien, vol. ii.

‡ Palæontographical Society.

‖ Memoires de la Société Geol. de France. Palèontologie, Mem. ii., 1893. This Memoir I have not seen. I am indebted for a knowledge of it to the Memoir by Williamson and Scott. See next reference.

§ Phil. Trans., vol. clxxxv. (1894) B., p. 934.

On the affinities of *Sphenophyllum*, with regard to which different authorities hold different views, the researches referred to throw little or no new light. They confirm, however, the conclusion that in the *Sphenophylleæ* we have a group which cannot be classed with any of the existing types of Vascular Cryptogams, but they still leave open the question as to where their nearest allies are to be looked for.

KALOXYLON HOOKERI, Will.

Among Carboniferous plants with structure, there are few or none whose sections present a more striking appearance than those placed in the genus *Kaloxylon*. The genus was instituted by Williamson in 1876, to receive a number of specimens which he described under the name of *Kaloxylon Hookeri*,* and which he treated as fragments of stems or branches. Further specimens in different stages of development were described and figured by him in 1887,† and it was then suggested that the least developed specimens were probably rootlets, but the older specimens were still treated as stems.

Some years later, Williamson made a re-investigation of the structure of *Lyginodendron* in association with Dr. D. H. Scott, and in the course of the work the important discovery was made that *Kaloxylon* is the adventitious root of *Lyginodendron*, and not an independent plant at all. In 1894 they communicated a joint paper to the Royal Society,‡ from which it appears that they had succeeded in finding "specimens, presenting in every respect the typical *Kaloxylon* structure," "in actual continuity with the stem of *Lyginodendron*," and arising from it in such a way as, taken with the anatomical structure, proved that they were roots.

In ignorance of all this, I was myself investigating the structure of *Kaloxylon Hookeri*, as shown in a number of fine preparations by

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* Phil. Trans., 1876.

† Phil. Trans., 1887.

‡ Proceedings, vol. 56.

Mr. Binns, partly in my own cabinet and partly in the Cash collection of sections of fossil plants at the Manchester Museum, Owens College. On anatomical grounds alone the conclusion was first reached that all the forms of *Kaloxylon*, without exception, were roots. The question then arose as to whether these roots could be brought into relation with any of the known Carboniferous stems, and attention was directed to this point. In the end it became evident that certain characteristic and critical tissues of *Kaloxylon* were actually identical with the homologous tissues of *Lyginodendron*, and that this was not the case with any of the other Carboniferous types. On this ground the inference was made that the plant fragments known as *Kaloxylon Hookeri* were the roots of *Lyginodendron*, the various forms being simply different stages in their development. A paper embodying my observations and deductions was communicated to the Manchester Literary and Philosophical Society* on the 31st of May last year, which by a singular coincidence was the day on which the previously communicated paper by Williamson and Scott, was read at the Royal Society.

Thus by independent methods and by independent workers, the conclusion has been reached that the specimens of *Lyginodendron* and *Kaloxylon* are the stems and roots respectively of one and the same plant, and as such they must henceforth be placed together.

LYGINODENDRON AND HETERANGIUM.

The two genera placed at the head of this section were both instituted by Williamson in 1873, who at the same time gave descriptions and figures of the specimens on which they were based.† In subsequent communications to the Royal Society‡ he made further additions to the knowledge gained in the first instance, and finally undertook a complete re-investigation of them in conjunction with Dr. D. H. Scott. As a result of this joint work, a memoir on the structure of the vegetative parts of *Lyginodendron* and *Heterangium* was sent to the Royal Society in the Spring of this year, in which our knowledge of their anatomy and histology appears to have been carried as near completion as the specimens at present to hand will permit. The Memoir itself is not yet available, but its great importance is obvious from the abstract which has already appeared in the Proceedings.*

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* Mem. and Proc , 4th ser., vol. ix., 1894-5.

† Phil. Trans., 1873.

‡ Phil. Trans., 1874, 1876, 1887, 1890.

With respect to the affinities of these plants, the authors of the Memoir have arrived at most interesting and important conclusions, which cannot be passed over without at least a brief reference. Students of palæobotany will remember, that Williamson's earlier view was, that both genera belong to the Ferns. In accordance with this, he included them in the third part of the General, Morphological, and Histological Index to his Memoirs,† which deals with Ferns, and pointed out that they approximate so closely to one another, in their structure, as to convince him that they both belong to the same division of the Fern family. The new investigations have led to an important modification of this view, and he and Dr. Scott are now of opinion that "the evidence afforded by the vegetative characters" of *Lyginodendron* and *Heterangium*, "clearly points to a position intermediate between Ferns and Cycadeæ." It is admitted, in the abstract above-mentioned, that the leaves of *Lyginodendron*, and probably those of *Heterangium* also, are unmistakably Filicinean, but on the other hand it is pointed out that the structure of the stems is very suggestive of Cycadean affinities. After discussing the possible affinities with various groups of Ferns, the view finally suggested by the authors is, that the two genera "are derivatives of an ancient generalised race of Ferns, from which they have already diverged considerably in the Cycadean direction. Of the two genera, *Heterangium* appears to be geologically the more ancient, and certainly stands nearer to the Filicinean stock. *Lyginodendron*, while retaining conspicuous Fern-like characters, has advanced much further on Cycadean lines." From this brief reference it will be obvious that in this Memoir we have the record of an important increase of our knowledge of these two interesting types of Carboniferous plants, and it is not impossible that it may be the starting point for a further advance at an early date.

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* Proc. of the Royal Soc., vol. 58.

† Mem. and Proc. of the Manch. Lit. and Phil. Soc., 4th ser., vol. viii., 1893-4.

LEPIDODENDRON AND ALLIED FORMS.

The work done upon *Lepidodendron* and the forms allied to it, since 1891, though good and useful of its kind, has not resulted in such great advances as those already referred to in connection with other types. In a memoir, published two years ago,* Williamson made a further contribution to our knowledge of the structure and organisation of *Lepidodendron Harcourtii*, and gave an account of the structure of the leaves. He also brought forward a large body of fresh observations on the fossils known as *Halonia* and *Ulodendron*, with the object of showing that they are merely the fruit-bearing branches of *Lepidodendra*, and not independent plants as is sometimes supposed. Finally, by the aid of specimens supplied by Mr. Lomax, he was able to demonstrate that the twig described in the Sixteenth Memoir† as *Lepidodendron Spenceri*, is the axis of the peculiar strobilus or fruit-spike, with winged spores, described and figured in the Ninth Memoir,‡ so that both structures are really parts of one and the same plant.

His last independent memoir was issued in the spring of this year, only a short time before his death.|| In it he endeavours to elucidate the growth and development of the arborescent *Lepidodendra* of the Coal Measures by a study of the details of their organisation. In the result some of the views expressed on these matters in previous memoirs are more or less modified, and, to some extent at least, brought into harmony with those held by other palæobotanists.

The fruit-spikes of *Lepidodendron* have been studied by Prof. Bower with results that have an important bearing upon certain morphological questions. His account of the structure of the axis of *Lepidostrobus Brownii*, Schimp.,§ brings to light quite a number of histological details which had previously escaped the notice of palæobotanists, and which led him to institute a comparison of the stem of *Lepidodendra* with those of existing Lycopodiaceous plants. The results cannot be detailed here, but amongst them is the interesting

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* Phil. Trans., 1893, B.

† Phil. Trans., 1889. ‡ Phil. Trans., 1878.

|| Mem. and Proc. of the Man. Lit. and Phil. Soc., 4th series, vol. ix., 1894-5.

§ Annals of Botany, vol. vii., pp. 329-354.

conclusion, that, all things considered, the anatomical structure of *Lepidodendron* approximates most closely to that of the *Psilotaceæ.*

The structure of the Sporangia of *Lepidodendron* is described with some detail in his elaborate memoir on The Morphology of the Spore-producing Members of the *Equisetineæ* and *Lycopodineæ.*[*] Here it is shown that the sporangia of *Lepidodendron* are of two types. In *Lepidostrobus Brownii,* Schimp., "the sporangial wall is several layers of cells in thickness, and the cavity traversed by rod-like masses of tissue (trabeculæ), while, in other forms, the wall consists of a single layer when mature, and the cavity traversed by one or more irregular plates of sterile tissue." In both cases, however, the sterile tissues spring from the floor of the sporangium, which projects into the cavity to form the "sub-archesporial pad," and, though it is not proved, it seems probable that they are similar in their origin to the trabeculæ of *Isoetes.*

MYELOXYLON, Brongt.

In a paper on this genus of Carboniferous plants,[†] whose affinities have hitherto been more or less undecided, Mr. A. C. Seward brings forward a number of fresh observations in support of the view that it agrees more closely with recent Cycads than with Ferns. They are based upon specimens of *Myeloxylon* from the Millstone Grit, sections of petioles in the Binney Collection, in the Woodwardian Museum, Cambridge, and a preparation in the Williamson Collection. It is not pretended that the evidence these specimens afford is sufficient for a final decision on the affinities of *Myeloxylon,* but it seems to bear out, to a large extent, the author's conclusion that "*Myeloxylon* should be looked upon as an extinct genus, not exactly corresponding to any recent family of plants, but one which comes very near to the Cycadeæ in anatomatical structure, and probably occupies a position between Cycads and Ferns, but nearer to the former than to the latter."

In another paper[‡] the same author describes a new Fern from the Coal Measures, under the name of *Rachiopteris Williamsoni.*

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[*] Phil. Trans., vol. clxxxv. (1894) B.

[†] Annals of Botany, vol. vii., pp. 1-20.

[‡] Annals of Botany, vol. viii., pp. 207-218.

The description is based upon sections in the Williamson Collection, which had been previously referred to the genus *Myelopteris*, a synonym of *Myeloxylon*, Brongt.

CONCLUSION.

The record of progress set forth in the preceding pages may, I think, be justly described and without exaggeration, as a remarkable one, especially when it is borne in mind that it is a record of work done within the narrow limits of four years. Looking back at the history of British Palæobotany during the last half century, it may be doubted whether any previous period, of equal length, has produced more good and solid work than this. Not only so, but it will be noticed that the advances made have not been restricted to one direction only, a point to which a few concluding words may appropriately be devoted.

In the first place it may be noted that the investigation of the structure and development of fossil plants has been made more searching and critical, and has been pursued along the same lines and by the light of the same morphological conceptions, as the investigation of existing plants. This is a branch of the subject which, though less striking perhaps to palæontologists in general, is of the highest possible importance, and is often indeed the indispensable condition for progress in other directions. I regard it therefore, as of good omen for the future of British palæobotany, that its methods and objects are being approximated, as far as circumstances will allow, to those which prevail in the investigation of living plants.

In the next place considerable progress has been made by bringing together in their proper relations, as parts of one and the same organism, fragments of fossil plants which hitherto have been scattered and separated, the *disjecta membra* of organisms unknown. That there is much more to be done in this direction, no one can doubt who has any acquaintance with the subject, and the success already achieved should be an incentive to further effort. Such effort is all the more worth making since when succesful, the ground is cleared of a number of generic and specific names, which it renders superfluous, and this of itself is a great gain.

Lastly, on the question of affinities, our knowledge has advanced considerably, with the result that while some older views have been confirmed others have undergone more or less modification. In some cases, as in that of *Sphaneophyllum*, the fossil forms refuse to be incorporated in the groups formed by existing plants, and the system has to be enlarged in order to accommodate them. This, though troublesome in some respects for the time being, is a result which should be welcomed, as bringing us a step nearer to that system of classification which, at least approximately, will represent the actual course of evolutionary progress.

THE MALHAM DRY RIVER BED. BY THOMAS TATE, F.G.S.

(Communicated November 13th, 1895.)

Eighteen years ago this Society organised an exploration party for the purpose of ascertaining the origin of the River Aire. The diverse opinions held up to that time, are fairly summarised in the words of Whitaker :—" Speaking in general terms. the lake may fairly be considered as the source of the Aire ; but as its outlet quickly sinks into the ground, and is lost, and as several streams which appear below contend for the honour of the connection, it still remains a matter of some uncertainty to which of them the preference is to be given. The inhabitants of Malham plead that the waters of the Tarn actually appear again in two most abundant and beautiful springs about a quarter of a mile below the village, and nearly three miles from the place of immersion. This opinion seems most probable. But from the foot of the Cove, and almost a mile nearer to the Tarn, a copious stream breaks out, which has undoubtedly the second claim. Yet it is well known that a collection of springs rising in the Black Hills, the Hensetts and Withes, is swallowed up in a field called the Streets ; and from the turbid quality of the water, very unlike that of the Tarn, there is little doubt that, after a subterranean course of more than two miles, this is the stream which here emerges again. Thirdly, the Airton Water, from which the village derives its name, seems precluded by its distance from any reasonable pretensions. Fourthly, Gordale Water, which springs in the Great Close, and of which the whole course may be traced, can have no other claim than that of a collateral feeder." " West Yorkshire " contains the following account of the origin of this river :—" The River Aire has its source in several small streams rising in the moorlands at the foot of Fountain's Fell and Hard Flask. The principal stream runs from Capon Hall to the Tarn, and is joined by others in its passage. A second feeder, having its origin near Capon Hall, runs in a more southerly direction for about a mile over the Streets, and sinks in a cleft in the rock near an old smelting mill. The stream from Malham Tarn runs half a mile southward, and sinks through a large opening in the limestone. Nothing more is seen of the water until the foot of Malham Cove is reached. The water rushes in a powerful stream from an opening at the base of the Cove, and pursuing a southward course passes through the village of Malham, and half a mile below is joined by the stream from Gordale. The Aire then runs nearly due south through Hanlith and Airton to Bell Busk, where it is joined by the Otterburn."

These conflicting statements suggested a series of investigations that should determine, as far as possible, the actual source of the Aire, and a report, with full details of the work done, appeared in our Proceedings for 1879. It was found that the drainage off Hard Flask and Fountain's Fell into Malham Tarn, after flowing south for half a mile, disappeared in the "water-sinks," the bulk of the water reappearing at Airehead Springs, nearly three miles below the Tarn; the remainder emerging at the foot of the Cove.

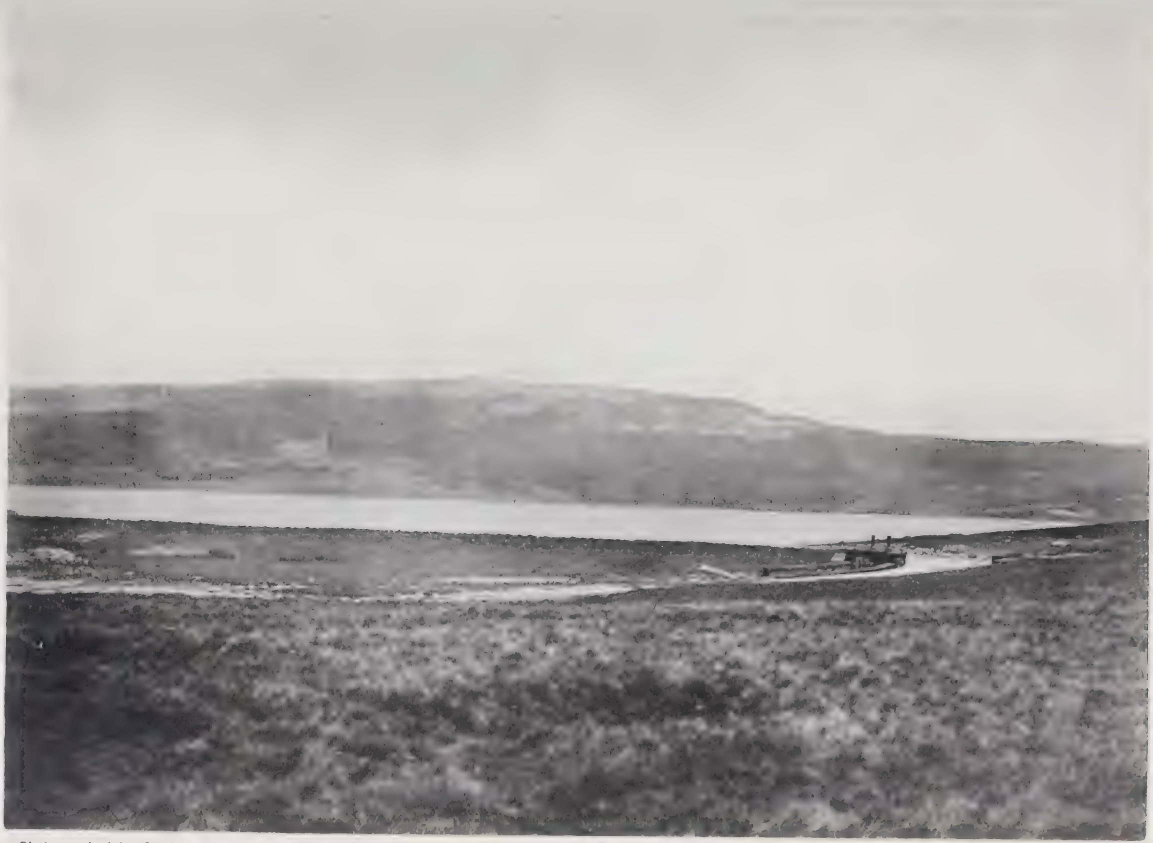
But the waters of the Aire have not always taken this subterranean course. Hurtley, the Malham Schoolmaster, writing in 1786 says :—"From the apex of this Cove, after what is in this part of the country called a RUGG, or a succession of rainy and tempestuous weather, when the water-sink at the southern extremity of the Tarn is unable to receive the overflux of the Lake, there falls a large and heavy torrent, making a more grand and magnificent cascade than imagination can form any idea of. This vast and precipitate cascade, so generally enquired after, and so seldom seen by travellers, in the summer months hath been so much admired as to leave it equally subject of wonder and concern, that the inlets of the stream which might easily be done, have not been stopped, and this lofty and imperious cataract thereby rendered a perpetual object of gratification and astonishment." "Twice within the last forty years the *swollen waters* of the Tarn have made their way over the Cove, but the torrent was dispersed in one vast cloud of spray before it reached the bottom. Its density and the magnificent sight may be imagined from the fact that the spectators could not approach within a hundred yards of the foot of the rock without being drenched through." (Howson).

A dry river bed, extending from the water-sinks to the summit of Malham Cove, forms a marked physiographical peculiarity of this elevated area which, as remarked by Phillips, can be distinctly followed. Yet it is no exaggeration to say, that every summer thousands of pleasure seekers wander in close proximity to this charming dry valley, and pass on unconscious of its existence. This interesting geological and topographical feature is fully illustrated in the following series of admirable photographs, for which the Society is deeply indebted to Mr. Godfrey Bingley, of Leeds. The skill and good taste of the photographer in selecting his points of attack awaken the warm admiration of those who know the difficulties of the situation and the labour which must have attended their production. They give an artistic and accurate representation of the whole length of this interesting little gorge, and on the map, which is added, the place from which each photograph was taken, and the direction of view is indicated by a numbered arrow-head.

(No. 1)—MALHAM TARN (alt. 1246 ft.) View looking north, across the Tarn to Tarn House (the seat of Mr. Walter Morrison, M.P.), with Malham Moor in the background. The sluice-gates are seen at the foot of the Tarn. Silurian rocks occupy the foreground and constitute the floor of the Tarn; the moorlands beyond the house are of Mountain Limestone. The stream leaving the Tarn crosses the north branch of the Craven fault near the Wate-sinks Gate, and the fault may be seen in Gordale Beck, to the east.

(No. 2)—THE WATER-SINKS (1200 ft.), half a mile below the Tarn. Here the waters are swallowed up by fissures in the Mountain Limestone, some of which may be seen at the base of the wall to the right, but the sinks occur chiefly for a short distance down the valley, on the other side of this boundary wall. When the photograph was taken there was no water passing down the water-sinks, the sluices being closed. "Malham Water, a lake embosomed in the cloud-capped mountain (Gray) which, hiding itself as it were immediately on its escape from the parent's confines, traverses the bowels and cavities of the earth till it finds a snug and serene retreat amid the almost inaccessible crags at the foot of Cove." (Hurtley).

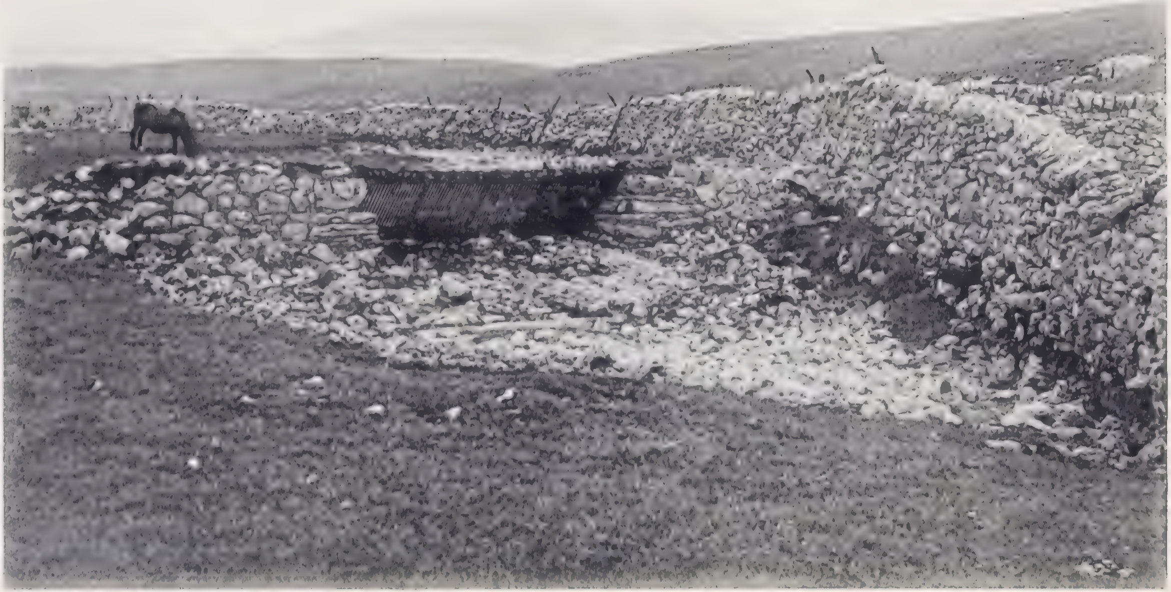
(No. 3) COMB SCAR (1220 ft.) entrance to the north end. View



Photographed by Godfrey Bingley, Headingley, Leeds.

1. MALHAM TARN.

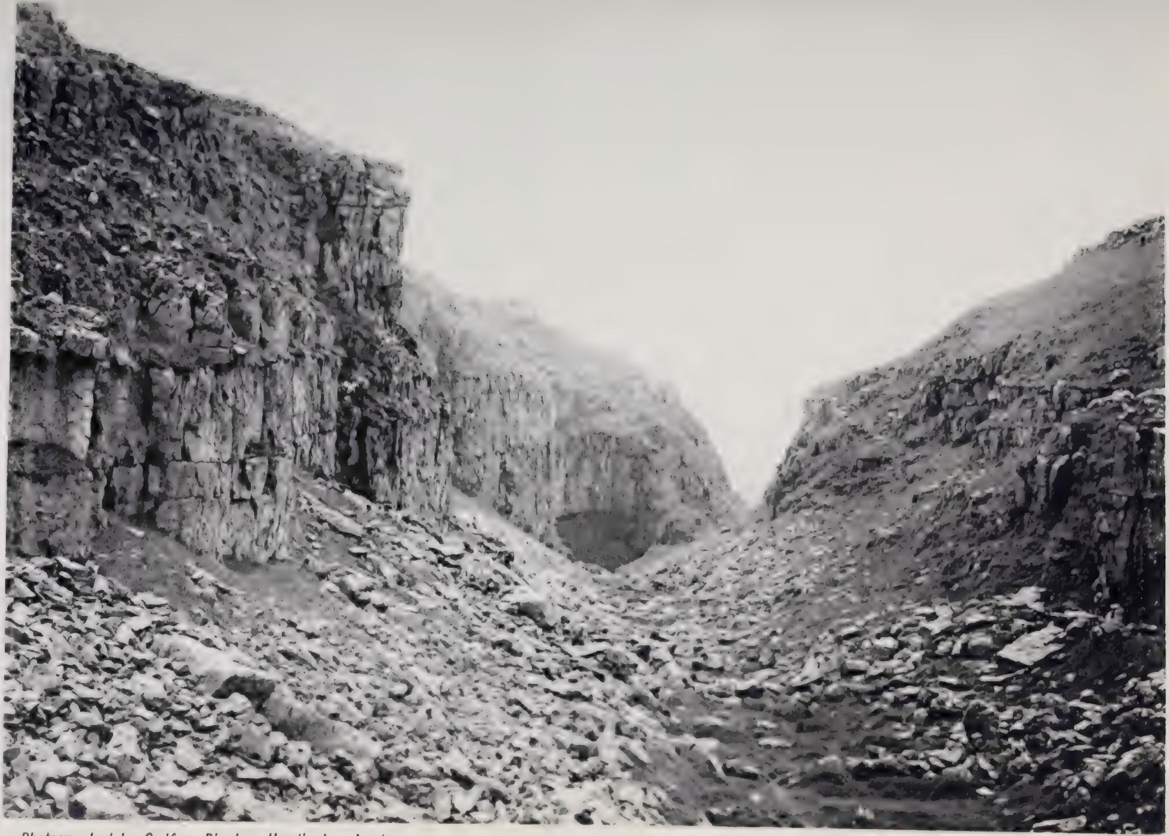
Proc. Yorks. Geol. and Polyt. Soc., Vol. XIII., Plate VI.



Photographed by Godfrey Bingley, Headingley, Leeds.

2. THE WATER SINKS.

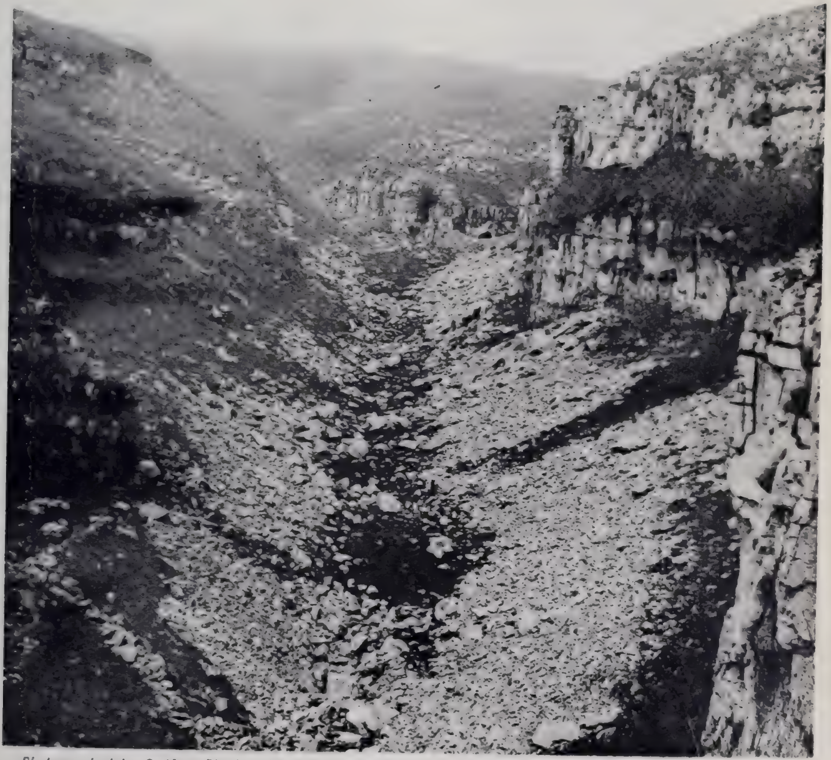
Proc. Yorks. Geol. and Polyt. Soc., Vol. XIII., Plate VII.



Photographed by Godfrey Bingley, Headingley, Leeds.

3. COMB SCAR (LOOKING SOUTH).

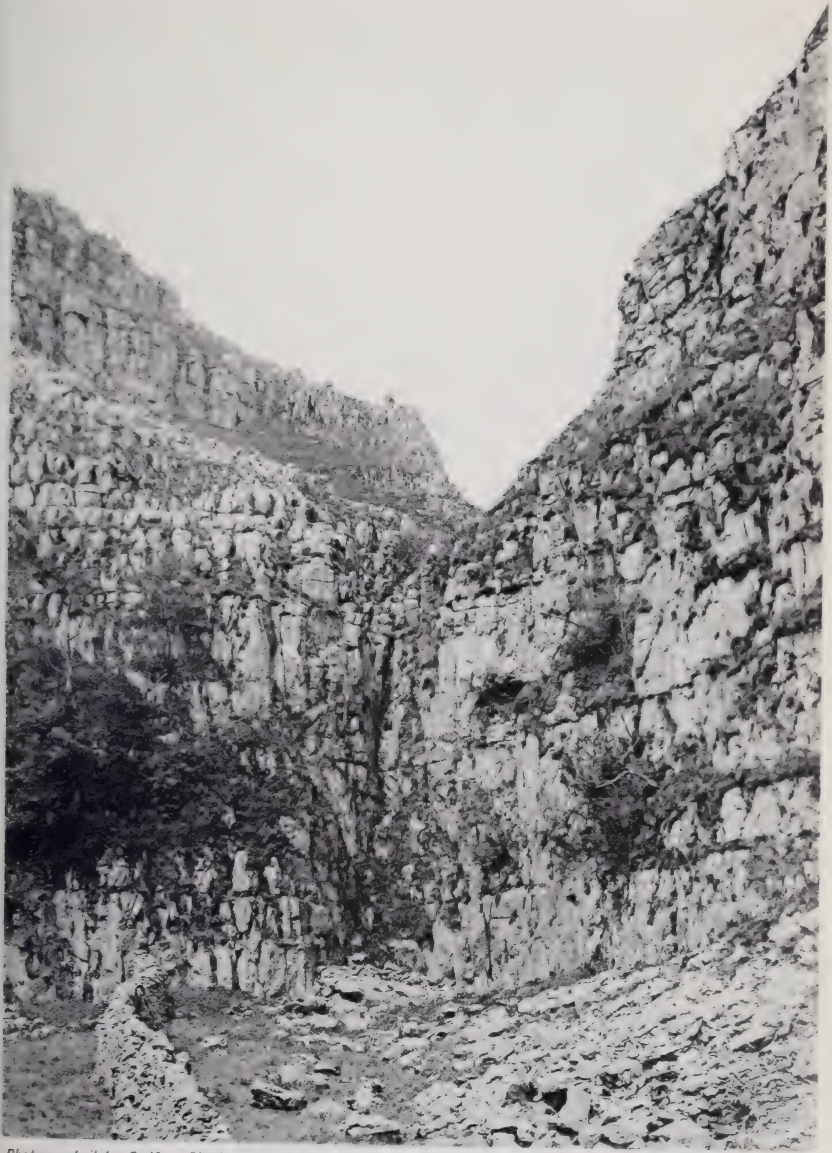
Proc. Yorks. Geol. and Polyt. Soc., Vol. XIII., Plate VIII.



Photographed by Godfrey Bingley, Headingley, Leeds.

4. COMB SCAR (Looking North).

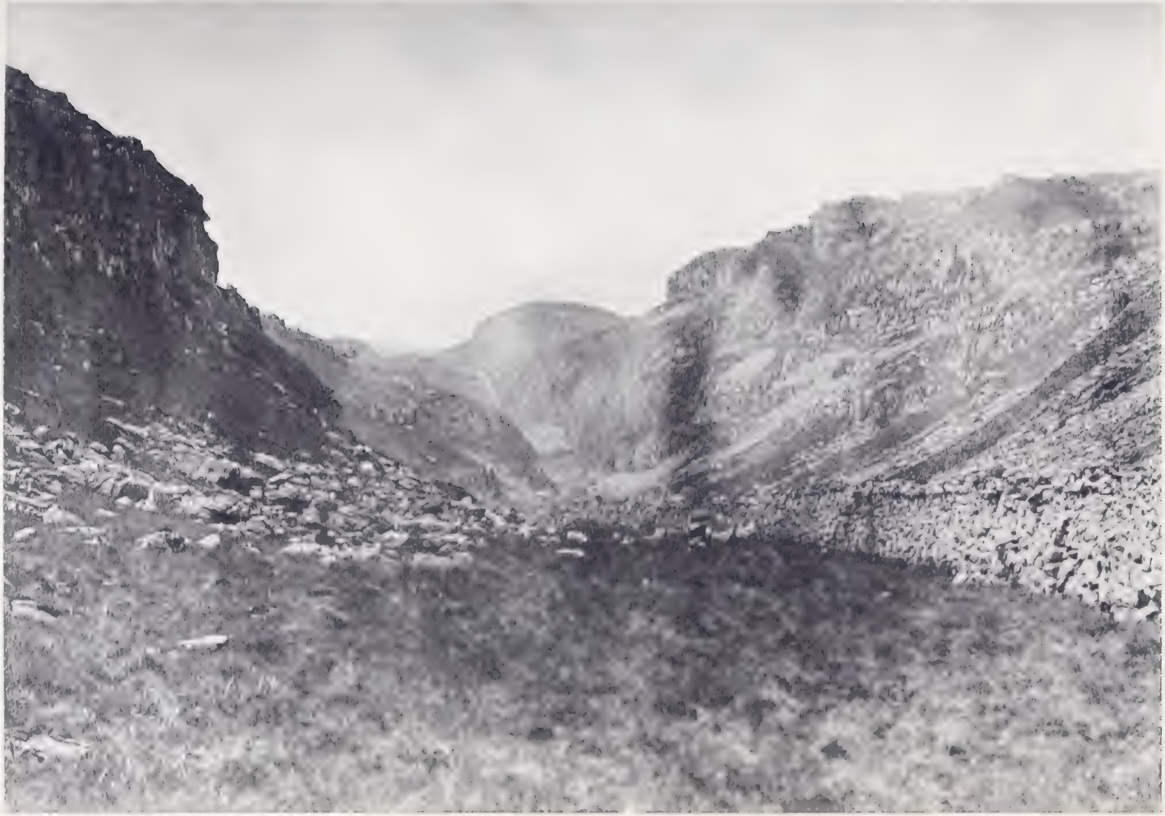
Proc. Yorks. Geol. and Polyt. Soc., Vol. XIII., Plate IX.



Photographed by Godfrey Bingley, Headingley, Leeds.

5. DRYWATER FALL.

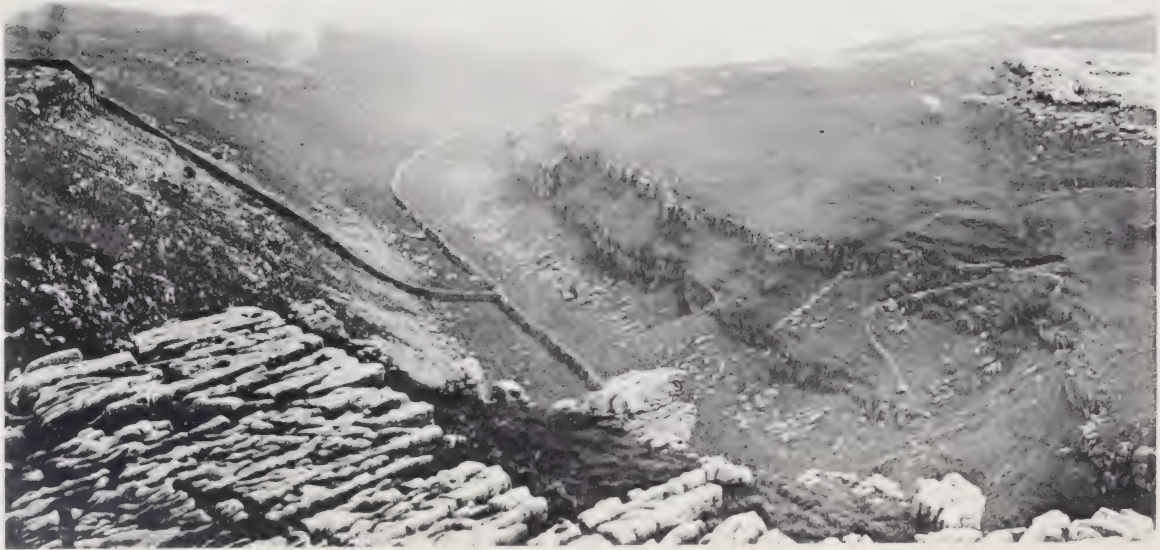
Proc. Yorks. Geol. and Polyt. Soc., Vol. XIII., Plate X.



Photographed by Godfrey Bingley, Headingley, Leeds.

6. VIEW FROM FOOT OF COMB SCAR (Looking North).

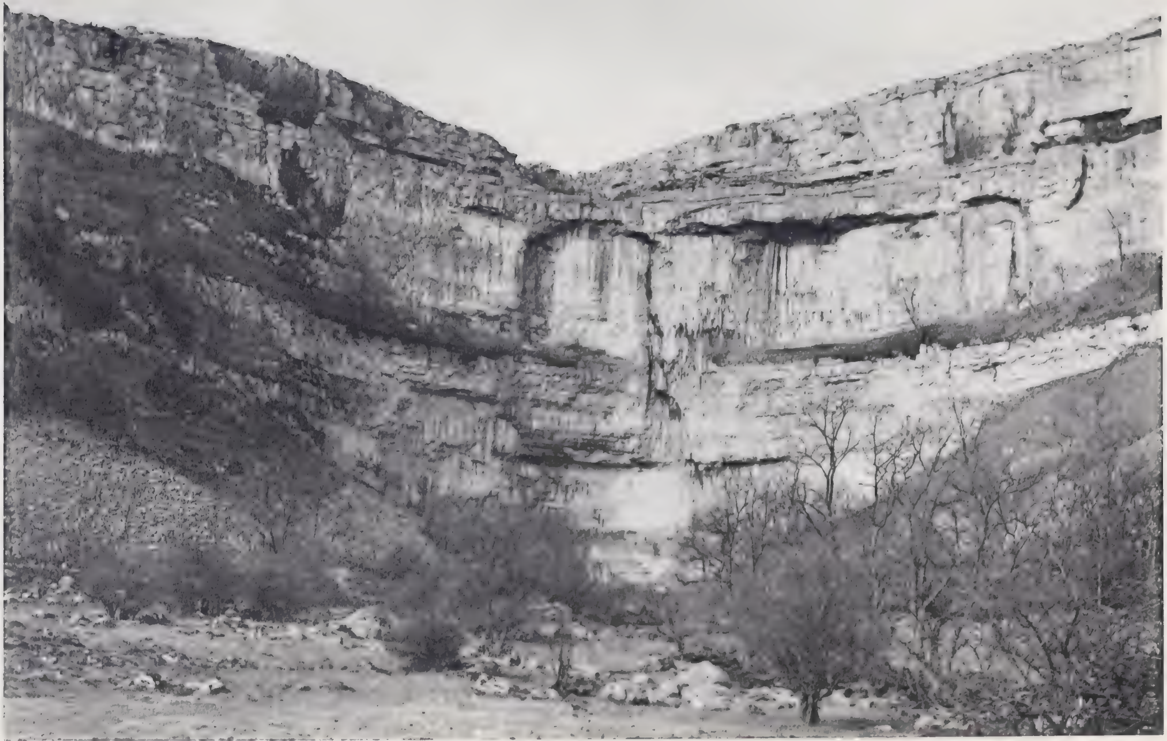
Proc. Yorks. Geol. and Polyt. Soc., Vol. XIII., Plate XI.



Photographed by Godfrey Bingley, Headingley, Leeds.

7. VIEW FROM SUMMIT OF COMB SCAR ALONG THE WATLOWES.

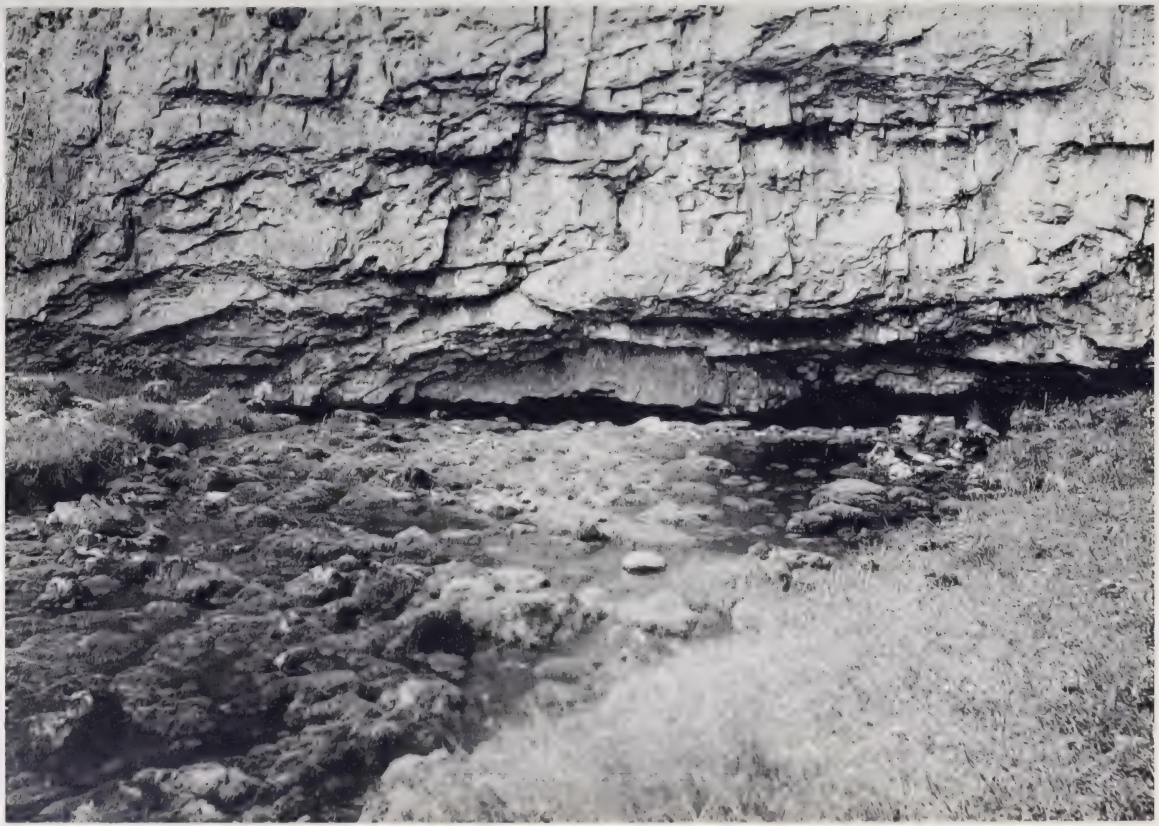
Proc. Yorks. Geol. and Polyt. Soc., Vol. XIII., Plate XII.



Photographed by Godfrey Bingley, Headingley, Leeds.

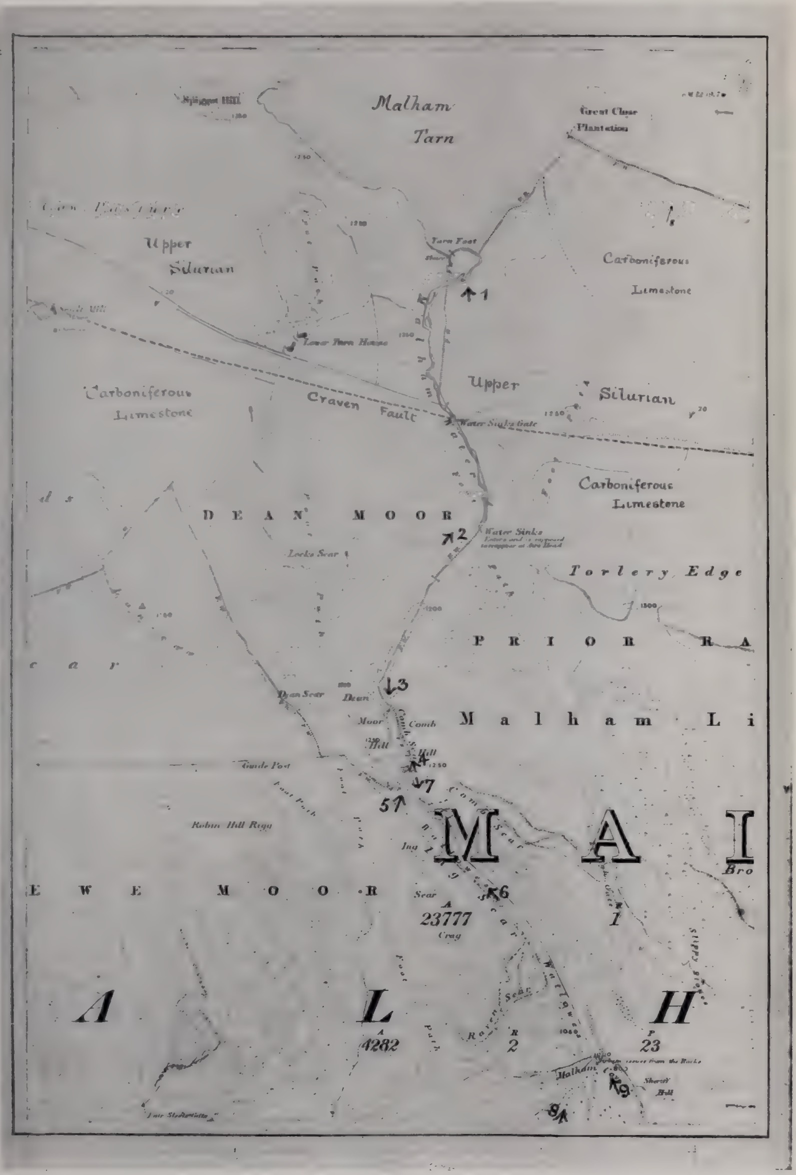
8. MALHAM COVE.

Proc. Yorks. Geol. and Polyt. Soc., Vol. XIII., Plate XIII.



Photographed by Godfrey Bingley, Headingley, Leeds.

9. CAVERN AT FOOT OF MALHAM COVE.



10. MAP OF THE DRY VALLEY OF THE AIRE.

Proc. Yorks. Geol. and Polyt. Soc., Vol. XIII., Plate XV.

looking south. Scar limestone stratified in thick, nearly horizontal, beds, showing typical weathering.

(No. 4) COMB SCAR (1200 ft.) looking north, from a point about two hundred yards below No. 3. The floor of the dry river course is nearly covered by the talus frosted off the vertical joints of the limestone.

(No. 5) DRY WATERFALL between Dean Moor Hill on the left and Comb Hill to the right, looking north. Through much of its course the surface channel of the Aire broadens out, but here, where the primitive river bed makes a sharp bend, it is contracted between precipitous vertical cliffs. Over this precipice, old writers have described a magnificent waterfall, as to be seen after heavy rains. " In a flood the Tarn water not unfrequently rushes over here and forms a second Gordale, but is commonly prevented from reaching the Cove by sinking at the foot of this pass through the shattered and fissured stratum, with singular noise and rapidity." (Howson). This writer also narrates a touching incident occurring here eighty-five years ago :—A boy, bird-nesting, lost his hold and falling was killed. His younger brother, happily ignorant of death, went down and shook him, but, said the little one, " he was asleep."

(No. 6) THE WATLOWES. View taken on floor of dry valley, at the foot of Comb Scar, looking north. The precipice seen in the previous view, is here concealed by a bend of the dry river course to the east, round the base of Dean Moor Hill, the central eminence in this view. The Scars on the right show magnificent weathering.

(No. 7) FISSURAL LIMESTONE PAVEMENT in left corner. Surface weathering into curious rugose hollows and fantastic shapes, with projecting knobs, ridges or pinnacles (often used for rustic work). This is the characteristic surface weathering of limestone developed in high bare tracts of exposed country. Another fine example (" The Woolpacks ") may be seen behind the Cove. This view is taken from the top of Comb Scar, looking south, down into the dry valley below the Watlowes, as far as the summit of the Cove (near mid-skyline).

(No. 8) MALHAM COVE (1000 ft.) The dry valley ends about the middle of the skyline. From this depression the " magnificent cascade," described by Hurtley, descended to the foot of the Cove, a distance of two hundred and fifty feet. The semicircle of limestone cliffs, some seventy yards across, may be traversed along a ledge or natural terrace, about eighteen yards up the face of the Cove. "The tints and colouring of the Cove as it appears at present, are naturally the softest and most elegant that can be conceived. The Rock is silver-grey, delicately although irregularly striped with lines of dark hue, occasioned by the streams of water falling from the *Saxa Sedilia* or shelves in various places and directions ; and the entire Mass is embroidered and interspersed with shrubs and evergreens, forming together by a variety of shades and features, an Alcove and Landscape the most splendid and picturesque." (Hurtley).

(No. 9) WATER CAVERN at the foot of Malham Cove, whence emerges a portion of the water disappearing at the sinks. In the foreground is Malham Beck which, lower down, is joined by Gordale Beck and (after receiving the water from Airehead Springs) the Otterburn to form the River Aire.

(No. 10) MAP OF DRY VALLEY. Reduced from Ordnance Sheet No. 133, showing :—

(*a*) The station and direction of each photograph.

(*b*) The geological evidences of the Craven Fault.

Botanists may be interested to learn that the following are among the rarer plants observed hereabout :—*Trollius europæus*, *Actæa spicata*, *Draba muralis*, *Thlaspi alpestre*, *Hutchinsia petræa*, *Helianthemum canum*, *Geranium sanguineum*, *Potentilla alpestris*, *Pyrus aria*, *Blysmus compressus*, *Sesleria cœrulea*, *Polypodium calcareum*, *Aspenium viride*, *Equisetum hyemale*, *Verrucaria Malhamensis*, and *Lecidea ribidula*.

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Naturalist, January, 1892.

NOTES ON A ROMAN COIN FOUND IN GRASS WOOD, GRASSINGTON, BY THE UPPER WHARFEDALE EXPLORATION COMMITTEE.

Extract from Vol. II. page 831. Records of Roman History on Roman Coins, by Francis Hobler.

"CONSTANTINOPOLIS, — 3rd Brass of Constantinus Magnus. *Obv.* A female head with laureate and crested helmet to the left, bust in armour; over the shoulder the staff of a spear is projecting. *Rev.* No legend. In the exergum T.R.P. A victory standing on the prow of a galley, to the left, with a spear in the right hand; her left hand rests on a shield."

ADDITIONAL REMARKS BY WILLIAM FENNELL.

The female head represents Rome. The *condition* is unusually *perfect*, and the refinement of the features very striking. The presence of the *laurel crown* encircling the helmet is so uncommon, that while observing many hundred coins of the Constantine period, I have not come across one.

Constantine the Great was born A.D. 274, died 337.

T.R.P. means, coined at Trèves. TREVERIS percussum. TREVERIS being the Roman name of Trèves.

This coin was probably minted after the seat of government was removed from Rome to Byzantium (330 A.D.), and the idea of representing Rome by a female head was continued, by representing Constantinople in the same way.

NOTE BY ERNEST E. SPEIGHT, B.A.

This coin was found in August, 1895, by Mr. William Hill and James Birch, at the root of a shrub taken from the centre of an enclosure near the Park Stile, Grass Wood. The exact spot was the highest enclosure on the N. side of the pathway which leads from the Park Stile entrance to Gregory, just above the place where several millstones were found. Near the coin was found the antler-hafted knife which is also among the 'finds.'

NOTES ON THE WHITE CHALK OF YORKSHIRE.

BY G. W. LAMPLUGH, F.G.S., OF H.M. GEOLOGICAL SURVEY.

CONTENTS :

Introduction ... ... p. 65.
Part I. The Thickness of the Chalk ... p. 66.
Part II. The Small Faults of the Chalk ... p. 77.

INTRODUCTION.

At the outset I may at once state that with regard to these notes, while I hope hereby to render available some fresh information respecting the White Chalk of Yorkshire, there will be no attempt on my part to deal adequately with the whole subject. My chief aim will be to supply details which may forward and lighten the labours of its future investigators. My knowledge of the deposit is the result of the somewhat desultory observations made during the leisure hours of the twenty busy years which I spent in the vicinity of Flamborough Head.

I commenced to collect fossils from this grand range of cliffs while still a school boy, and am glad even yet to enjoy occasionally the keen relish of the collector on the discovery of a "good specimen" in these rocks. As time went on I began to realise that in spite of the past labours of Phillips, Barrois, Blake, and Mortimer, there remained the necessity for a vast amount of patient and somewhat tedious investigation before our knowledge of the Yorkshire Chalk could be placed on a really satisfactory basis ; and this led me to make measurements and records of some of the sections. Probably if I had remained much longer in the locality, and no other worker had come forward, I should eventually have taken the subject seriously in hand, and should have tried to submit the Upper and Middle Chalk to the same thorough study as Mr. W. Hill has accorded, with such excellent results, to the lower part of the formation.*

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* W. Hill, "On the Lower Beds of the Upper Cretaceous Series in Lincolnshire and Yorkshire. Quart. Jour. Geol. Soc., 1888, vol. xliv., p. 320.

As matters now stand, however, my attention has been directed to "fresh groves and pastures new," and I see no prospect of pursuing this investigation further. Therefore it seems advisable that I should in some rough form put forward my scattered observations for the use of workers more favourably placed for completing the study.

In the present instalment I propose, as far as I am able, to discuss the thickness of the Chalk, an aspect of the subject which may at any time have an important practical bearing. In future communications I hope, on similar lines, to treat of the palæontology of the deposit; of the conditions of accumulation as indicated by the state of the fossils; and of some of the effects of consolidation and of later earth-movements.

I. THE THICKNESS OF THE CHALK.

It may truly be said that at present the Upper and Middle Chalk of Yorkshire is geologically little better than a desert province, whose boundaries have indeed been accurately defined, but whose interior is trackless and unexplored. Its monotonous sameness; the paucity, except in a few localities, of its organic remains and the frequently unsatisfactory state of their preservation; together with the isolated and limited character of its sections everywhere save on the sea coast, render exceptionally difficult the task of fixing and tracing horizons within it. For these reasons, since the effect of the faults and disturbances which undoubtedly traverse the formation cannot be accurately determined, it is probable that in the interior of the East Riding the thickness of the Chalk will never be more than approximately ascertainable, unless, of course, by deep boring.

Therefore it is to the coast section that we must turn in search of more precise information. Even here, however, there are serious difficulties, by reason of the almost inaccessible position of some of the sections, and the interrupted character of others. Hence there have been remarkably few really serious attempts to measure these sections. Young and Bird* were content, with regard to the thickness of the Chalk, to state that it "cannot be less in some places than 600 feet;" Phillips† was equally indefinite, placing it at "not less than 500 feet;" while the calculations of Barrois,* who estimated a depth of 643 feet, were admittedly based on data acquired during a single traverse of the ground. Blake,† who followed, seems to have made some careful measurements in the cliffs on the south side of Flamborough Head, but did not carry these far enough even to reach the base of the Flintless Chalk, and for the lower divisions used figures obtained chiefly by calculations of dips and position. By these methods he attains a total of 790 feet, which though in excess of any of his predecessors' results is still, as I shall be able to show, very considerably below the actual thickness of the rocks.

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* Young and Bird. Survey of the Yorkshire Coast (1822), p. 47.

† Phillips J. Geology of the Yorkshire Coast, 3rd ed., p. 50.

More recently Mr. W. Hill,‡ in the very careful study of the Lower Chalk already alluded to, has published a detailed measurement of the beds below the Flinty Chalk, as seen in the cliff near Speeton, giving for these beds (including the Red Chalk) a thickness of 153 feet, as against the 72 feet allotted to them by Barrois, or the 100 feet by Blake. My own measurement of this exposure has served but to confirm the accuracy of Mr. Hill's figures.

In the Memoirs of the Geological Survey on the district || no original information is given as regards the total thickness of the Chalk; and so far as I am aware, the above quoted are the only published statements directly bearing on the subject, though some useful data may also be gathered from the late Mr. R. Mortimer's paper "On the Flints of the Chalk of Yorkshire,"§ and that of Mr. J. R. Mortimer, on "The Chalk Water Supply of Yorkshire."¶

The additional information which I now propose to bring forward has been almost entirely derived from the detailed measurement of the strata as they rise into the cliff on the southern side of Flamborough Head, supplemented by as close an examination as circumstances would permit of the less accessible sections on the northern

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* Barrois C. Recherches sur le Terrain Crétacé Supérieur, vol. i., p. 201. Mémoires de la Société geologique du Nord, 1876.

† Blake J. F. Proc. Geologists Assoc., vol. v., p. 232.

‡ Hill W. On the Lower Beds of the Upper Cretaceous Series in Lincolnshire and Yorkshire. Q. J. G. S.. vol. xliv., p. 320 (1888).

|| Memoirs of the Geological Survey. "Oolitic and Cretaceous Rocks south of Scarborough" (1880); "Bridlington Bay" (1885); "The country between York and Hull" (1886); "Driffield" (1886).

§ Proc. Geologists Assoc., vol. v. p. 344.

¶ Proc. Instit. Civil Engineers, vol. lv., p. 252.

side of the promontory, and by a consideration of the evidence afforded by the inland sections in the vicinity of Bridlington.

The full account of these measurements is, for convenience of reference, given below (see Appendix, p. 80). This record gives the details of an unbroken sequence of strata from the base of the cliff below Sewerby Park, where the mensuration of each individual layer first becomes practicable, eastward for 1,400 yards, to the vicinity of the Danes Dike ravine. In this distance a thickness of 205 feet of Flintless Chalk is traversed. There is, however, for about 400 yards to the westward of the measured section. a cliff of Chalk composed of higher beds ; but these are so much disturbed by glacial action and so greatly obscured by slips that it has not been found possible to measure them in detail. I think that we should allow, at least, an additional 35 feet for these, thus bringing up the total thickness seen in the cliff to the westward of Danes Dike to 240 feet. This somewhat exceeds the result obtained by Blake, who places the depth to this point at 192 feet.

But it is almost certain, on both stratigraphical and palæontological considerations, that the Chalk of the rising ground south-west of Bridlington comprises a considerable thickness of higher beds than the uppermost layers represented in the cliff-sections ; and though the depth of these higher strata has not yet been accurately determined, I believe that they cannot fall below 100 feet, and not improbably are much thicker.

The valley at Danes Dike causes a gap in the cliff-section which is somewhat difficult to span. There is much disturbance of the bedding, both in the low-water scars and in the cliff on the western side of the ravine ; and though this has undoubtedly been accentuated by superficial crushing in glacial times, it seems to be essentially a structure of more ancient date. It probably denotes the presence of a fault in this locality, of more considerable value than the numerous minor breaks presently to be discussed which almost everywhere in these sections intersect the Chalk. That there is not, at any rate, a downthrow to the eastward sufficient to cause a repetition of the strata, is established by the presence of the well-marked band containing abundant remains of *Marsupites ornatus*

(Appendix, p. 82) on the western side, and its absence from the eastern side of the gap; while that there is much vertical displacement in the opposite direction is also rendered improbable by the discovery by Mr. J. W. Stather of a single specimen of that fossil in the chalk immediately to the east of the valley.

I think, therefore, we may safely conclude that the value of any fault existing at this point cannot be great, and that its only possible effect can be slightly to increase the apparent thickness of the strata.

Westward from Danes Dike the prevalent gentle south-easterly dip becomes rather more pronounced, and there is consequently a more rapid rise of the layers into the cliff, so that in the distance of one mile which intervenes before the South Sea Landing is reached, the detailed measurements record a further thickness of 214 feet of Flintless Chalk. Blake mentions that beyond Danes Dike he measured 130 feet "as far as it was safe to go," and apparently stopped about midway between the above-mentioned places. There is, however, neither danger nor difficulty, excepting from the roughness of the way, in going along the beach at low-water, or even at half-tide, not only from Sewerby to South Sea Landing, but also for nearly two miles farther, to the extremity of the headland, where on the south side of High Stacks a rather steep but perfectly easy path leads up into the fields above.

At South Sea the line of section is again interrupted by a deep hollow which has been excavated in the Chalk down to sea-level in pre-glacial or glacial times and afterwards filled in with drift. The low-water scars are, however, very nearly continuous across the little bay, and so far as can be seen there is no sign of any change in the regularity of the strata in traversing it.

Farther east there is an unbroken cliff-section extending for nearly two miles, quite to the extremity of the headland, in which the Chalk throughout is flintless. In this area there is, however, a slight change in the direction of the dip, which here inclines towards the south, and occasionally even a little to the westward of south, and at an angle rarely reaching so much as 4 degrees; and as the effect of this is to bring the line of strike very nearly into coincidence with the cliff-line, the strata retain their position in the section for long stretches almost without alteration of level. Hence my measurements yield a further thickness of 105 feet only for the beds between South Sea and the base of the cliff on the southern side of High Stacks, where the first line of scattered nodules of grey flint is seen. (Appendix, p. 84.)

In hammering along the section it has always seemed to me that there is a very pronounced increase in the hardness of the chalk as the extremity of the headland is approached, and that besides the emergence of the more compact layers towards the base of the Flintless Chalk there is an actual induration of the rock as a whole in this direction. This is a point worthy ot closer investigation, and if studied in connection with the numerous indications of compression and intimate rearrangement which the rock presents, might yield results of interest. The molecular movements necessary to the formation of the masses of flint in the underlying strata may be partly responsible for this induration, but a more probable cause is the proximity of the zone of contortion and faulting which is revealed in the cliff in Selwicks Bay, 300 yards northward of High Stacks.

It is to be noted that up to this point there is a complete absence of flint nodules in the Chalk: and the qualified descriptions which have been applied to this portion of it, as containing "little or no flint," "almost destitute of flint," etc., are therefore rather misleading. If any silica be present it is invisibly disseminated throughout the mass of the rock,* or is incorporated in the fossil sponges, and is nowhere segregated into "flints."

From the above figures it appears necessary that we should assign to the Flintless Chalk of the vicinity of Flamborough Head a total thickness of not less than say, 650 feet. This doubles the highest previous calculation, namely that of Professor Blake, who estimated its depth at 320 feet. And as it is more than probable that beds higher than any of those of the Flamborough and Bridlington area exist beneath the mantle of drift which covers Holderness, we can readily understand the statement that at Hornsea the well-sinkers have passed through 800 feet of Flintless Upper Chalk.*

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* See "On the Flints of the Chalk of Yorkshire," by R. Mortimer. Proc. Geol. Assoc., vol. v. p. 349.

With regard to the underlying Chalk-with-flints, which now demands consideration, my data are less adequate. From High Stacks I managed with some difficulty to measure the beds northward as they rise into the cliff as far as Common Hole, on the southern side of the Bay of Selwicks, up to which point I found the thickness of the Flinty Chalk to be 76 feet. (See Appendix, p. 85). But beyond this violent contortions occur, and then a fault, already described to this Society.† The fault has a downthrow to the north which I estimated (but probably rather overestimated) at 80 feet, and its effect is to bring down the Flintless Chalk to the base of the cliff on the northern side of Selwicks, and therefore to repeat, in the sections beyond, the strata included in the measurement just given; so that it is only in the cliffs north-west of Stottle Bank Nook, quite inaccessible, except by boat under favouring conditions of tide and weather, that any lower beds appear.

It has long been my intention to continue the investigation from this point by the aid of a boat, but I have never yet found a favourable opportunity. Consequently my knowledge is only such as

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* C. Reid. Survey Mem. Geology of Holderness, p. 6., and p. 141; See also "On the Flints of the Chalk of Yorkshire," by R. Mortimer, Proc. Geol. Assoc., vol. v., p. 349; Mr. Mortimer supposed, however, that in this boring the whole of the Chalk formation was penetrated and its base reached; on this and other grounds he argued that the Flintless Chalk passed laterally into the Flinty Chalk, but the field evidence offers no support to this view. It is perhaps unsafe to lay much stress on the result of this boring in the conflictory state of the evidence with regard to it. All the data, and especially the absence of Flint, seem to show that the boring did not reach the Middle and Lower Chalk. Yet Mr. W. H. Crofts has favoured me with the following note which he recently obtained from the well-sinker:

"A borehole done in 1862 and 1863, at Hornsea, in a brickyard, for Mr. Wade.

Boulder Clay, sand and gravel ...	depth	120 feet
Thickness of Chalk rock below ...	...	858 ,,
Total depth ...		978 ,,

Below this depth was soft black warp or clay."

The "black warp or clay" seems to have been regarded by the well-borers as underlying the Chalk; but possibly it may have been merely a thin marl band interstratified with the Chalk, as seams of this character occur at intervals throughout the Yorkshire sections.

† Lamplugh G. W. "On a Fault in the Chalk, etc." Yorksh. Geol. and Polyt. Soc. (1880), vol. vii., p. 242.

could be gained by examination from the edge of the cliff, and by a descent in the two or three places where it is possible to scramble down with the assistance of a light rope, supplemented, of course, by the closer study of the accessible sections at the North Sea Landing and the Thornwicks.

So far as these methods enable me to judge, there are beds at the base of Cradle Head lower than those which I have measured, and at Brail Head the cliff is composed entirely of Flinty Chalk, which is, therefore, about 140 feet thick at this point.

Professor Blake has given good reason for basing sub-divisions of the Flinty Chalk on the mode of occurrence of the flint, recognising, in downward succession, the following zones :—

No. 2.	Chalk with imperfect flints	120 feet.
No. 3.	Chalk with many tabular flints	50 ,,
No. 4.	Slaty Chalk with thin flints ... ... Creamy Chalk with nodular flints ...	200 ,,
		370 ,,

In the coast section, Zone No. 3 of this scheme probably forms the lower half of Brail Head, and rises to the top of the cliff about 100 yards to the westward of the picturesque King and Queen Rocks, where there are thick tabular masses of flint in the Chalk. I think that somewhat less than 120 feet should, however, be allowed in this locality for the thickness of the overlying "Chalk-with-imperfect-flints ;" and that for this division 100 feet will probably be an extreme estimate.

In the vicinity of the North Sea Landing and Thornwick the westerly trend of the cliff-line coincides nearly with the direction of strike, so that unless there are concealed faults in the little bays to affect the level, there is probably not much change of horizon between these points, the lowest beds being reached at low-water mark under the outstanding ridges of this rugged coast. These cliffs do not exceed 125 feet in height, inclusive of the capping of drift which is often thick. But westward from Sarnwick the ground rises steadily, so that at Gull Nook, three quarters of a mile farther west, there is a precipice 270 feet in height, consisting entirely of Flinty Chalk, with an inconsiderable covering of glacial deposits. The dip is still southward, at an angle of under 5°, and as the trend of the cliff in this neighbourhood is west-north-west, a slow rise of the strata is presented, apparently nearly corresponding with the rise of the ground. Hence in the section at Gull Nook it is probable that the beds which form the headlands at Thornwick are still present. Beyond this point the cliffs continue for one mile farther of about the same height and general tendency, until Old Dor is reached, where the strata are plunged suddenly in violent contortions, magnificently displayed in a slightly overhanging precipice 290 feet deep. This fine section was illustrated by a series of photographs issued by the Society in 1885, accompanied by a short descriptive article from the pen of our lamented Secretary, the late Mr. J. W. Davis.

The contortions continue for about 200 yards and then as suddenly cease. To estimate and eliminate the effect of this disturbance in measuring the Chalk is an exceedingly difficult problem. I have thrice reached the spot from below; but these visits were all hurried, and they failed to give me any clue. I could not identify any particular band amid the maze-like twistings; and although there are several small fractures crossing the strata, I could not see any clear indications of faulting. It is indeed highly probable that there is a fault at this place, but so far as one can judge the displacement is not likely to be large. If the fault ran inland across the strike and its throw were considerable in either direction, it would, in the interior, shift the boundary between the Flinty Chalk and the Chalk-without-flints, and I have traced this boundary at intervals from Flamborough to Speeton without detecting any important break. There is still, of course, the possibility of the fault being in the direction of the strike, and so remaining wholly within the Flinty Chalk in this area; and I am indeed inclined to believe that a displacement of this character does exist in the Bempton Valley; but, even if this be the case, its dimensions cannot be large. On the whole, therefore, I think we may disregard this disturbance without vitiating our results. I suspect that its general effect is to slightly carry down the base of the Flinty Chalk on the north-western side of the contortions, that horizon being probably only a little depth below sea-level on the opposite side.

For the next three-quarters of a mile the vertical cliff is still composed from top to bottom of Flinty Chalk, and the flints at the summit are in thick tabular masses, showing, if other evidence were wanting, that at this horizon we are considerably below the top of the flint-bearing strata. The base of the cliff in several places rises from the sea at all states of the tide, and the uniformly resistant character of the rock is shown by the simple wall-like outline of the precipice. But beyond Kit Pape's Spot (oddly miscalled Kit Pape's *Pot* on the old 6-inch Ordnance Map) a rocky foreshore begins to show at low tide, and is continuous and traversable from this place to the ending of the Chalk cliffs at Speeton, over two miles distant.

The appearance of this foreshore marks the place where the base of the Flinty Chalk rises above low-water and the less resistant Lower Chalk is brought up to receive the direct battering of the waves. At this point a fine spring of fresh water wells forth from the foot of the cliff a few feet above low-water mark, a welcome spot for anyone who on a hot day makes the toilsome journey over the bouldery beach from Speeton.

We have here 325 feet of Chalk-with-flints in one section, and as just mentioned, the summit of the section is still considerably below the top of the division. It is therefore evident that Blake's estimate of 370 feet is inadequate, and of course still more so Barrois' of 260 feet, and that even the 400 feet allowed by Phillips is not sufficient, though it is not easy to determine how much should be added.

I think, however, we may safely reckon 30 or 40 feet in addition to the height of the cliff for the depth of the Chalk-with-tabular-flints, and about 100 feet more for the Chalk-with-nodular (or "imperfect") flint, of which latter 76 feet was actually measured in the section east of Selwicks.

This gives us a total of 460 for the flint-bearing Chalk; and a consideration of the pits and other sections in the interior will show that this is not likely to be an overestimate. In walking inland at right angles to the cliff, we go nearly along the direction of the dip, and consequently almost directly across the bedding; yet the breadth of the outcrop of the Chalk-with-flints is never less than half-a-mile in width, and where there is a pronounced inland slope of the ground, as at Bempton, the outcrop expands to nearly a mile.

With regard to the remaining portion of the series, comprising the Lower Chalk and Red Chalk or Hunstanton Limestone (which together are equivalent to the Grey Chalk, Chalk Marl, and Upper Gault of the South of England), we have precise information in the invaluable paper by Mr. W. Hill already referred to. This author found the thickness of the Lower Chalk in the cliff at Speeton to be 132 feet; and that of the Red Chalk, which forms the base of the section, to be 30 feet.

According to these data, then, the total thickness of the Chalk in the vicinity of Flamborough and Bridlington is approximately about 1250 feet, made up of the following sub-divisions:—

Upper Chalk without flints	+650 feet.
Middle Chalk with flints	460 ,,
Lower Chalk	130 ,,
Red Chalk	30 ,,
Total	1270 ,,

This total exceeds by more than one-half the highest previous estimate. Even then, if the evidence of the Hornsea boring may be trusted, the full thickness attained by the Upper Chalk farther south in Holderness has not been recognised, and if allowed for would materially increase the above figures. And if for any purpose it should hereafter be deemed advisable to attempt to pierce the deposit, the facts herein dealt with will require to be borne carefully in mind.

So far as I am aware, within the limits of the British Islands it is only in the Isle of Wight that the Chalk formation has had so great a thickness as this assigned to it.

There, according to the recent work of Messrs. Reid and Strahan,* the total depth is over 1750 feet. Near Norwich about 1200 feet has been proved; but elsewhere in the Eastern and Midland Counties, the thickness of the deposit is usually estimated at from 500 to 800 feet.

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* Memoirs of the Geological Survey. Isle of Wight. 2nd ed., p. 75.

It is almost certain that both in the Norfolk and the Isle of Wight sections, higher zones of the Chalk are represented than are known to occur in Yorkshire. In these areas the higher beds are characterised by the presence of *Belemnitella mucronata*, while in the highest known part of the Yorkshire sections *Belemnitella quadrata*, which marks an inferior horizon, alone has as yet been recognized. The higher zone may perhaps exist beneath some portion of drift-covered Holderness, and the greater thickness which the Upper Chalk appears to possess in this area may thus be accounted for. It is at any rate quite evident that in the Flamborough and Bridlington district a considerable but unknown quantity of rock has been stripped off by denudation, and that the original thickness of the Chalk formation has been much greater than it now is.

That portion of the Chalk which is present in the Flamborough sections quite probably, however, attains its maximum thickness in this district. With the insufficient evidence in hand it is not indeed possible to institute a direct comparison of the thickness of any particular portion in these sections with its thickness in the regions to the westward and southward, except the lowermost part of the series. But the general tendency of the whole of the Secondary rocks of Yorkshire is to reach their greatest development in the eastern part of the area, and to become thinner towards the west and south, and this is probably shared by the Upper Cretaceous strata. In the Red Chalk this tendency is strikingly evident, and, as Blake and Hill have demonstrated, it is also very decided in the Lower Chalk. It is however scarcely likely, from the uniform character of the deposit, that the westerly decrease is maintained at the same high proportion in the Middle and Upper Chalk as in the lower divisions. Yet it is probably sufficiently great to reduce considerably the aggregate thickness of the Upper Cretaceous rocks in that quarter. It will be no easy matter to gather the data necessary for the elucidation of this point, but I think that much might be done by a careful study of the fine sections opened out within the last few years in the construction of the railway across the Wolds from Driffield to Market Weighton, and by the comparison of these exposures with the above described cliff-sections.

PART II. THE SMALL FAULTS ('JOINT FAULTS') OF THE CHALK.

A notable feature of the Yorkshire Chalk is the multiplicity of the small faults by which it is intersected. These are probably everywhere prevalent, but can only be studied in sequence in the coast section, and it is also only there that their frequency becomes clearly evident. In the detailed examination of the Chalk cliffs my attention was necessarily arrested by these faults, as they caused some difficulty in measuring the various strata. It then occurred to me that although the displacement caused by any single fault rarely exceeded a foot or two, if their effect were cumulative their aggregate value might be very considerable. To test this point I commenced, while measuring the strata, to note down every fault I could detect in a given area, with the amount and direction of its throw. In this manner I collected the details relating to fifty-nine such faults occurring in consecutive sequence between Danes Dike and South Sea Landing, and eleven more, making seventy in all, to the eastward of the South Sea.* These details are fully set forth at a later page (Appendix B, p. 86). The observations have been combined in the following diagram, in which the number of displacements and the *net* total value of downthrow, in feet and inches, in the various directions are stated. Thus, for example, a reference to the appendix will show that there are fourteen faults in all with downthrows to the north-eastward, and that their sum gives a vertical displacement of 11 feet 1 inch; and so on. (Pl. xvi.)

This method of analysis has proved that my initial surmise that these faults might be cumulative in one direction is not correct. I imagined that a dislocation of low hade coming up from more consistent strata into a rock so full of joints and fissures as the Chalk, might be split up into numerous branches and dispersed over a considerable breadth of ground. But in this case the analysis would have shown a strong preponderance of downthrow towards a definite quarter; whereas it will be seen from the diagram that the displacements are so evenly dispersed that if the dial be divided along the north and south line the sum of downthrow on the western half will almost exactly balance the eastern, the figures being as follows :—

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* Another set was measured in the cliff between Sewerby and Danes Dike, but the record has been misplaced, and I am therefore unable to incorporate it in these notes.

WESTERN HALF.

Number of faults, 37. Amount of displacement, 32 feet 3½ inches.

EASTERN HALF.

Number of faults, 33. Amount of displacement, 33 feet 5 inches.

The closeness to coincidence of these figures is perhaps in part accidental. Indeed, an attempt which I have recently made to verify the figures has shown that this must in some degree be the case, since owing to new slips in some portions of the cliff, and the removal of the previously fallen material by the sea in other places, a list compiled now would be slightly different from that of four or five years ago. But that the general effect of the faults is to nullify each other, and not to accumulate the throw in one direction, has received full confirmation.

It is noteworthy that only if divided in the north and south direction can the halves of the dial be made to balance, and that their inequality becomes the greater the farther this line is departed from. If, for instance, the division be made from west to east the following result is obtained :—

NORTHERN HALF.

Number of faults, 23. Amount of displacement, 18 feet 9 inches.

SOUTHERN HALF.

Number of faults, 47. Amount of displacement, 46 feet 11½ inches.

When the faults are recorded consecutively as they occur in the cliff, it will frequently be found that for a short space the majority present displacements approximately in the same direction, thus roughly grouping themselves into sets; but as the field of observation is enlarged the counterbalancing effect of the various groups becomes evident. The displacements, therefore, are neither due to the splitting up of a single fault nor to the letting down of small wedges between expanding joint-walls.

It would require that a more extended series of these faults be studied before a really safe basis for deduction as to their structural significance could be attained. But I think that it is probable they may represent the sinking in of a broad low arch, and that they replace what in more coherent and less fissured rocks would have taken the form of wide undulations of the bedding. This subject deserves further investigation, and I commend it to the attention of East Yorkshire geologists.

APPENDIX A.

No. 1.—Cliff-section of the Chalk-without-flints between Sewerby and Danes Dike, Flamborough Head.

NOTES.—The measurements are recorded in descending order, from Sewerby eastwards. Many of the beds were measured in greater detail than recorded below, but, to save space, the various layers have been combined where no reason existed for keeping them separate. It is to be noted that the measurements, though carefully made, were not repeated. It was my intention to have gone over them all again and to have sought to arrange the strata into natural divisions, either by their fossils or otherwise, which was not, however, carried out. The following, therefore, is little more than a rough draft of the section, but it is sufficient to show the thickness of the chalk.

The beds which are most conspicuous in the sections are marked †; I expect that these will be readily recognised and will afford convenient base-lines for any worker who may desire to fill in fuller palæontological details.

The terms used in the description may be arranged in scale, thus:—Shaly Chalk when divided by bedding-planes into very thin layers; Platy Chalk when in layers 1 or 2 inches thick; Flaggy Chalk when the layers are 3 or 4 inches thick; Thickly-bedded Chalk when thicker than the above; Compact Chalk when the rock weathers evenly in thickish beds; Fissile Chalk when it breaks into thin "biscuity" fragments in weathering.

DESCRIPTION OF STRATA.	THICKNESS. Feet.	THICKNESS. Inches.	REMARKS.
Thin flaggy Chalk with marl partings.	about 35	0	Estimated thickness of the disturbed chalk in the obscure section west of Sewerby Park. The fossils are chiefly *Ventriculites cribrosus*, Phill., and other similar sponges, and some crushed Echinoderms, probably including species of *Micraster* and *Holaster*. A large univalve shell allied to *Pleurotomaria*, sometimes found in loose blocks on the beach, probably comes from this horizon. An *Ammonite* also occurs, but is very rare. (These and the following fossil notes will be found very inadequate. I intended to fill in the palæontology in the field after completing the section, but have not yet been able to do so.)
Compact Chalk in thicker beds	4	0	
Flaggy Chalk with marl partings	3	0	
Compact band	1	8	Forming the base of the cliff under the trespass-board in Sewerby Park. Crushed Echinoderms the chief fossils.
Compact band with two shaly layers above ..	1	7	
† Three flaggy layers of equal thickness, with thin marl above and below	0	10	An easily traceable horizon, which may be followed for some distance, and gives a useful indication for obtaining the value of the small faults in this part of the section.

Flaggy Chalk in thinnish layers	4	8	
Compact band	1	8	
Softer platy broken layers	4	6	Farther north, thins to 3 feet. Fossils:—sponges: Inoceramus, etc.
Harder, more compact band	2	1	
Shaly layers with marly base	1	2	
Harder platy Chalk	1	3	
Compact band	2	0	Many sponges in this part of the section = "Sponge-beds." The most abundant forms belong to the genera Scytalia (*Spongia radiciformis*, Phill. being the type); *Seliscothon* (*Spongia plana*, Phill. being the type); *Verruculina* (*Spongia convoluta*, Phill. being the type); *Siphonia* (*Spongia capitata*, Phill. being the type); and in the lower beds, *Stichophyma tumidum*, Hinde, and allied forms.
Platy Chalk with ¾ inch marl at base ...	1	0	
Compact bands with ¾ inch marl at base ...	4	2	
Alternations of flaggy Chalk and compact bands, with 1½ inches marl and soft Chalk at base	6	10	
Compact bands	3	6	
† Platy Chalk with marl above and below ...	0	5	
Flaggy Chalk with thin marl partings ...	5	0	
Compact band	1	4	
Platy fissile layers	5	0	
Shaly Chalk and marl	0	6	
Hard platy Chalk	3	8	
† Peculiarly thin "biscuity" Chalk and marl ...	0	3	
Rather shaly Chalk	2	1	Thin hard sponges of irregular outline, probably allied to the *Pachastrella convoluta* of Hinde; also *Pachinion* sp. as well as many of the forms occurring above. *Bolospongia globata*, Hinde, etc.
Flaggy Chalk	1	3	
Shaly Chalk and marl	0	5	
Flaggy Chalk	1	9	
Thicker-bedded Chalk	2	4	
† Marl seam (1 to 2 inches)	0	2	At base of cliff opposite the first of the large blocks of cemented Chalk-rubble on the shore west of Danes Dike,
Two compact bands with flaggy partings ...	3	0	
Platy Chalk	3	4	
Compact Chalk	2	4	Full of shell-fragments.
Platy and shaly beds with marl partings ...	1	2	
Platy fissile Chalk	18	0	Much shelly matter towards the top.
† Conspicuous marly layer (2 to 3 inches) ..	0	2	Well seen in small headland west of Danes Dike.
Flaggy compact Chalk	6	0	
Compact band	2	4	Forms base of headland just mentioned.
Hardish platy and flaggy Chalk .. about	8	4	Exact thickness rather doubtful. *Rhynchonella*, etc.
Marly layer	0	3	Sponges, including occasional large individuals of *Phymatella reticulata*, Hinde, and kindred forms.
Hard Chalk with two compact bands ...	3	0	Crushed shells.
Platy Chalk	2	9	
Two compact bands	2	2	
Carried forward	155	11	

APPENDIX A—*Continued.*

Description of Strata.	Thickness.		Remarks.
	Feet.	Inches.	
Brought forward	...155	11	
Flaggy and platy beds	8	8	*Marsupites ornatus* abundant = Marsupites beds.
Compact Chalk	1	10	
Platy Chalk with marl band at base	0	9	
Thickly bedded compact Chalk	3	0	
Platy beds	3	0	
Compact band	1	0	
Platy fissile Chalk	5	10	
Compact band	1	11	
Platy beds with marl partings	0	7	
Compact flaggy beds with thin marly layer at base	about 2	10	Measurement rendered doubtful by small fault.
Platy Chalk	3	0	
Compact band	1	5	
† Layer of marl and crushed Chalk	0	1	Implicated in the superficial (Glacial?) contortion on the west side of Danes Dike.
Flaggy and platy beds	about 18	0	Measurements rendered uncertain by disturbance of beds. *Marsupites ornatus* rare.
Compact harder band	1	6	
Chalk	about 30	0	Estimated thickness for the interval at Danes Dike where no Chalk is present in the cliff: only the uppermost 3 or 4 feet actually seen.
Total thickness between Sewerby and Danes Dyke	239	4	

No. 2.—Cliff-section of the Chalk-without-Flints between Danes Dike and South Sea Landing, Flamborough Head.

Description of Strata.	Thickness.		Remarks.
	Feet.	Inches.	
Platy fissile Chalk	about 25	0	Seen in the first cliff east of Danes Dike.
Fissile Chalk with much marl	1	6	
† Flaggy compact Chalk with 1 inch marl at base	2	4	Forms base of above cliff, but is best seen 20 yards farther east.
Alternations of flaggy Chalk and compact bands	17	0	A single specimen of *Marsupites ornatus* found by Mr. J. W. Stather at about this horizon.
Platy fissile Chalk	1	8	
Alternations as above, hard at base	8	4	
Flaggy layers	about 6	8	Exact thickness doubtful; cliff obscured by talus.
† Marly seam and crushed Chalk	0	6	Near the foot of the freshly-scoured cliff (in 1892)

				markings: *Echinoderms, Parasmilia* sp. (rare).
	Marl seam ...	0	1	
	Compact thick-bedded and flaggy Chalk ...	12	10	Badly preserved Sponges (*Scytalia*, etc.)
	Softer Chalk and thin marl partings ...	1	0	In these beds and various other parts of the section, the thicker layers are apt to split up and change their character when traced for a short distance, the more compact portions forming long lenticles.
	Two compact bands with platy partings ...	2	10	
	Platy fissile Chalk with marly partings ...	1	9	
	Compact band with crushed Chalk and marl at base ...	2	2	
	Flaggy Chalk with 1 inch crushed chalk and marl below ...	1	7	
	Compact Chalk ...	2	3	
	Flaggy Chalk with marl at base ...	5	6	Many ossicles of Star-fish.
	Compact and flaggy Chalk ... about	4	2	
†	Compact band ...	1	9	At base of cliff at west side of Hartendale Gutter.
	Shaly Chalk... ...	1	2	
	Compact layers with shaly base ...	2	2	*Inoceramus* fragments.
	Flaggy Chalk with several marl partings ...	12	6	*Ananchytes ovatus*, and *Inoceramus* fragments. Sponges.
	Thicker bands ...	2	10	
	Platy Chalk with layers of marl above and below	0	9	
	Compact band ...	1	11	
†	Marl seam ...	0	2	
	Thin platy Chalk and marl partings ...	4	4	
	Alternations of thicker and thinner bands with marl partings ...	15	8	
	Shaly Chalk with much marl ...	0	6	
	Hard flaggy Chalk ...	6	8	
†	Shaly Chalk with marl seams above and below...	0	6	At base of cliff below Beacon Hill.
	Thickish flaggy bands with marl partings ...	5	2	
	Shaly Chalk with marl seams above and below	1	2	
	Compact bands with flaggy marly partings ...	4	9	
	Flaggy Chalk ...	2	6	Shows oblique planes like cross-bedding.
	Flaggy Chalk with two compact thicker bands	8	8	
	Shaly Chalk and marl ...	0	9	
†	Harder flaggy Chalk ...	2	9	
	Softer Chalk and marl ...	0	4	
	Thick-bedded hard Chalk ...	3	0	At base of cliff in small headland west of South Sea.
	Crushed layer ...	0	8	
	Flaggy Chalk with 2 inches crushed at base ...	4	0	
	Hard thicker and thinner flaggy bands ..	14	4	
	Flaggy Chalk with marl seam at base ...	3	6	Outcrops in the buried cliff of Chalk on west side of South Sea,
	Hard flaggy Chalk ... about	6	4	On shore near the blocks of cemented gravel-breccia west of South Sea.
	Total thickness between Danes Dike and South Sea ...	214	4	

APPENDIX A.—*Continued.*

Section No. 3.—Cliff-section of the lower part of the Chalk-without-Flints between South Sea Landing and High Stacks, Flamborough Head.

DESCRIPTION OF STRATA.	THICKNESS.		REMARKS.
	Feet.	Inches.	
Compact flaggy Chalk	about 40	0	Seen in the cliff at the headland on the east side of South Sea; it is possible that the upper part may have been included in Section No. 2.
† Marl band with crushed Chalky layers ...	0	2	
Compact band	1	6	
Thin flaggy Chalk with marl at base ...	2	4	Marcasite crystals encrusting sponges.
Flaggy Chalk with marl at base	4	4	Occupying the base of the cliff for about 1½ miles, from East Nook to Cattlemere Scar. Fossils include small corals *(Parasmilia)*; ossicles of star-fish; spines of *Cidaris*, etc. *Infulaster (Cardiaster)* c.f. *rostratus*, Forbes, recently found rather abundantly at this horizon by Mr. J. W. Stather.
Platy and flaggy Chalk with marl at base ..	4	6	
Hard thin flaggy Chalk with marl at base ...	6	0	
Hard thin flaggy Chalk with marl at base ...	16	0	Between Cattlemere and the first small caves.
† Crushed Chalk and marl	0	3	
Hard flags with crushed chalk and marl at base	3	0	
Hard flags with thin marl seam at base ...	5	10	
,, ,, ,, ...	1	6	
,, ,, ,, about	7	10	Base just above high-water mark on south side of High Stacks.
Hard flags ... ... ,,	11	6	Exact measurement rather doubtful.
† FIRST FLINT: Seam of grey and yellowish flint nodules	...	..	At base of cliff under extremity of High Stacks.
Total thickness between South Sea and High Stacks	104	9	

Section No. 4.—Cliff-section of the Chalk-with-Flints between High Stacks and Common Hole, Flamborough Head.

DESCRIPTION OF STRATA.	THICKNESS. Feet.	Inches.	REMARKS.
† FIRST FLINTS: band of scattered grey and yellowish nodules	0	2	(See Section No. 3.)
Hard flaggy Chalk	8	0	
† Soft marl band	0	4	Weathers into gaps in the cliff on the north side of Green Stacks.
Hard flaggy Chalk	3	0	These beds seem to contain some flint nodules on the north side of the Selwicks Fault.
Platy marly Chalk	0	6	
Compact flaggy Chalk, rather lumpy	13	0	Specimen of Ananchytes partly filled in with flint and partly with Calcite
Band of small ramose flint nodules	...	...	Sponge workings?
Compact flaggy Chalk	2	6	
Band of flints, ramose and palmate	0	2	
Irregular lumpy flaggy Chalk	4	0	
Line of occasional flints of larger size than above	...	...	
Compact flaggy Chalk with flints in scattered nodules and occasional bands	14	0	Base of cliff under Fog-gun House.
Hard Chalk in thickish beds about	6	0	This and lower beds measured from the Common Hole side of the Fog-gun House.
Band of grey flints	...	..	
Compact flaggy Chalk	5	0	
Line of scattered flints and flint in joints	...	...	
Rather thickly bedded Chalk with many bands of thin palmate flints	13	0	
Compact Chalk	6	0	To half-tide level north of Common Hole.
Thickness of flinty Chalk between High Stacks Selwicks Bay	75	8	

APPENDIX B.

Details relating to the Small Faults intersecting the Chalk in the Cliff between Danes Dike and Old Falls, Flamborough Head.

FAULTS.	DIRECTION OF DOWNTHROW SIDE, AND AMOUNT IN FEET AND INCHES.																					REMARKS.
Number in sequence from West to East.	North.		N.N.E.		N.E.		East.		S.S.E.		South		S.S.W.		S.W.		W.S.W.		West.		N.W.	
	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	
1	...	...	...	...	...	...	...	...	3	2	...	...	...	...	...	...	...	...	...	...	...	...	East of Danes Dike.
2	...	...	...	...	...	...	...	...	0	1	...	...	...	...	...	...	...	...	...	...	...	...	
3	...	...	...	...	...	...	...	...	0	4	...	...	...	...	...	...	...	...	...	...	...	...	
4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0	1½	...	...	...	...	
5	...	...	...	...	...	...	...	...	0	10	...	...	...	...	...	...	...	...	...	...	...	...	
6	...	...	...	...	...	...	...	...	0	7	...	...	...	...	...	...	...	...	...	...	...	...	
7	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	...	...	...	...	...	...	
8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0	5	...	...	...	...	
9	...	...	...	...	...	...	...	...	...	...	...	...	0	2	...	...	...	...	...	...	...	...	
10	...	...	...	...	...	...	...	...	0	3	...	...	...	...	...	...	...	...	...	...	...	...	
11	...	...	...	...	...	...	...	...	0	6	...	...	...	...	...	...	...	...	...	...	...	...	
12	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	0	
13	...	...	...	...	...	...	...	...	0	5	...	...	...	...	...	...	...	...	...	...	...	...	
14	...	...	1	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Slickensides from W.N.W. dipping 20°.
15	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	0	
16	...	...	...	...	...	...	...	...	3	0	...	...	...	...	...	...	...	...	...	...	...	...	
17	...	...	...	...	...	...	...	...	...	...	...	...	0	7	...	...	...	...	...	...	...	...	
18	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0	3	...	...	
19	...	...	...	...	...	...	...	...	...	...	0	5	...	...	...	...	...	...	...	...	...	...	} Close together; east of Hartendale.
20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	...	...	...	...	
21	...	...	...	...	...	...	...	...	1	6	...	...	...	...	...	...	...	...	...	...	...	...	
22	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0	3	...	...	...	...	...	...	
23	...	...	...	...	...	...	...	...	0	3	...	...	...	...	...	...	...	...	...	...	...	...	
24	...	...	...	...	...	...	...	...	...	...	...	...	0	3	...	...	...	...	...	...	...	...	
25	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0	11	...	...	...	...	...	...	
26	...	...	...	...	...	...	...	...	...	...	...	...	0	8	...	...	...	...	...	...	...	...	
27	...	...	...	...	...	...	...	...	...	...	...	...	0	7	...	...	...	...	...	...	...	...	Rolling hade.
28	...	...	...	...	...	...	...	...	...	...	...	...	1	2	...	...	...	...	...	...	...	...	
29	...	...	...	...	...	...	...	...	...	...	...	...	2	10	...	...	...	...	...	...	...	...	
30	...	...	...	...	...	...	...	...	...	...	...	...	0	8	...	...	...	...	...	...	...	...	

																								next recorded.
34	...					1	10																	Signs of horizontal movement in adjoining marl bands. The following are east of Beacon Hill.
35	...			0	4																			
36	...					0	3																	
37	...					1	10																	
38	...			0	6																			
39	...															2	6							
40	...					0	5																	
41	...															0	8							
42	...					0	6																	Aggregate of three adjoining.
43	...					0	6																	At headland west of South Sea.
44	...						4																	
45	...															1	0							
46	...					0	7																	
47	...							3	10															E. by N. Aggregate of forking fault.
48	...	0	9																					N. by S.
49	...															1	4							Low hade: red loam in cavities.
50	...			0	4																			
51	...																	0	5					
52	...											0	6											
53	...													1	2									
54	...													0	6									
55	...					2	6																	
56	...					0	5																	
57	...															0	8							
58	...															0	9							
59	...					0	5																	
60	...															0	7							This and the following are on east side of South Sea.
61	...															1	0							Slickensides dipping at 15°.
62	...															0	8							
63	...															2	6							Aggregate of step-faults.
64	...					2	0																	
65	...															0	6							
66	...															0	6							
67	...					0	6																	
68	...															1	0							Two, adjoining.
69	...					0	6																	
70	...															1	3							West side of Old Falls, beyond which faults were not measured.
TOTALS	...	0	9	3	2	12	7	3	10	13	1	0	11	9	3	18	11	0	11½	0	3	2	0	

PARTICULARS OF STRATA AT GANSTEAD, IN HOLDERNESS.

BY JOHN STEARS.

(Communicated November 13th, 1895.)

In boring for a supply of water at Ganstead, five miles north-east of Hull, the following strata were passed through.

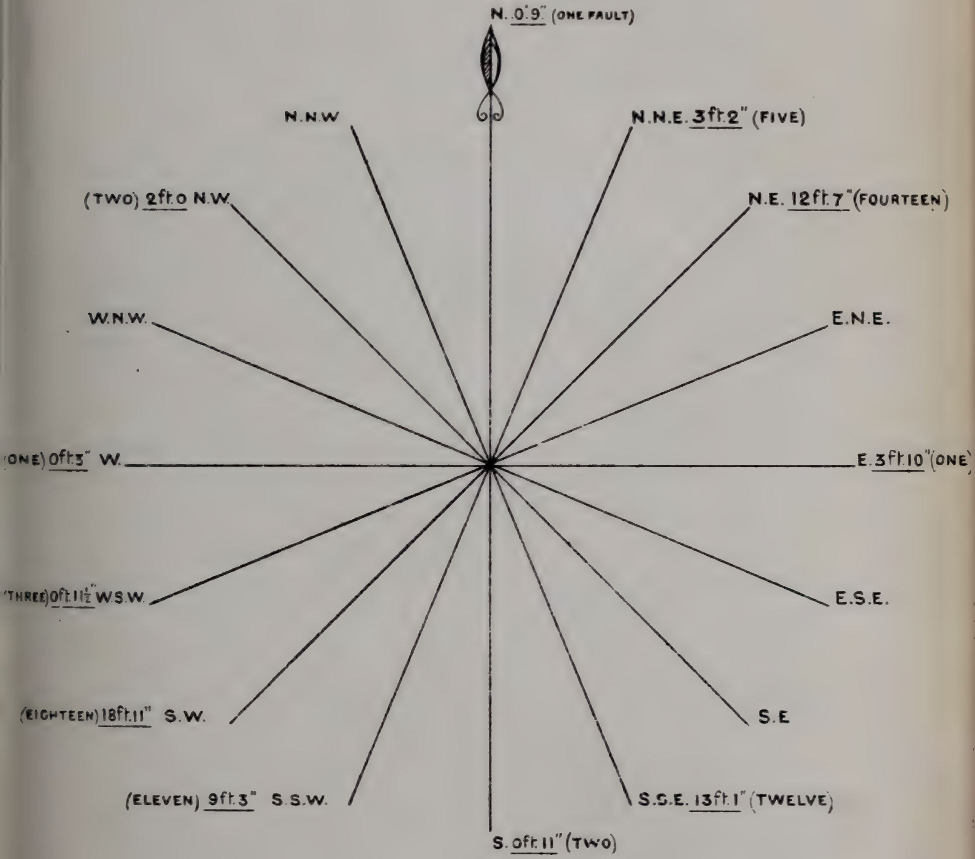
	Ft.	Ins.	
Soil	1	0	
Boulder Clay, containing many forams	53	0	
Sand, angular (no forams)	3	0	
Gravel ,,	10	0	Some water
Boulder Clay	13	0	
Sandstone Boulder	1	6	
Lower Boulder Clay was found containing pieces of chalk, forams, and small stones	8	0	
Sandstone Boulder	0	6	
Chalky Marl	12	0	
	102	0	

Loose Chalk to 110 feet; upon pulling out the auger the water rose 3 feet into the well, or 15 feet from the surface.

FORAMINIFERA FOUND IN BORING.

Rotalia Beccari,
Nonionina,
Polystomella striata,
Obulina universa,
Textularia variabilis,
Globigerina bulloides (very scarce),
Polymorphina lactea.

DIAGRAMMATIC SUMMARY OF SEVENTY SMALL FAULTS IN THE CHALK BETWEEN DANES DIKE AND OLD FALLS.



The number of the faults having the downthrow in the same direction is herein shown, with the total amount of their aggregate displacement for the various parts of the compass. The order and details of the faults are given in Appendix B.

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NOTES ON THE SUPERFICIAL GEOLOGY OF THE VALE OF YORK.

BY PERCY F. KENDALL, F.G.S., LECTURER ON GEOLOGY AT THE YORKSHIRE COLLEGE.

(Issued in connection with the General Meeting and Excursion, April 26th and 27th, 1895.)

The Vale of York is a very broad and ancient valley excavated in the soft sandstones and marls of the Permian and Triassic series, having a general easterly and north-easterly dip.

On the western side the valley is bounded by the gentle dip-slope of the Magnesian Limestone, while its eastern boundary is sharply defined by the bold escarpments of the Jurassic and Cretaceous rocks. The watershed on the north-east, separating the Ouse drainage area from that of the Tees, is in a most anomalous position, being within two miles of the main channel of the Tees, where that river has emerged clear of the hill-country. This condition is clearly a very modern one, and is connected, as I shall on some future occasion explain, with the irregular accumulation of the Glacial or Drift deposits.

Throughout the Vale of York the "solid geology" is extensively covered by superficial deposits, so much so indeed that its details are very largely a matter of conjecture, the Glacial deposits of the district having produced a surface configuration in all minor details quite independent of those of the underlying rocks, or, where conforming to them at all, doing so quite fortuitously.

In a paper published in the last volume of the Proceedings of this Society, I have drawn attention to some of the interesting problems connected with the Glaciation of Yorkshire without attempting to state any very definite conclusions, and I have utilised the admirable and accurate Drift maps of the Geological Survey to illustrate some of the more important Glacial features of the immediate neighbourhood of York.

I may briefly summarise the facts as I understand them :

A great glacier poured over the Cross Fell range of hills into Upper Teesdale, carrying with it large numbers of rocks belonging to the western drainage, such as Granites from Galloway, Brockram and the Dufton "Granite" from the Vale of Eden, and various igneous rocks from the Lake District, such as the remarkable diorite or gabbro of Carrock Fell, the quartz-porphyry of Threlkeld, and most notably the well-known granite of Shap Fell. This glacier gathered other characteristic rocks, such as the Whin Sill, in its passage down to the low grounds, and at one or more stages of its history it debouched into the North Sea.

While these events were in progress a great sheet of ice was advancing upon our east coast from Scandinavia, which doubled back all the native ice streams, turning some coast-wise to the northward, others to the southward, while yet others, probably including the Teesdale stream, were deflected into inland courses. Either the deflection of the Teesdale glacier was brought about in this manner, or the true explanation of the fact is that the Norse ice was already obstructing the mouth of the Tees when the native stream reached sea level. In either case the Teesdale glacier was driven over the watershed into the drainage valley of the Ouse and received a series of tributary glaciers flowing along the great dales down to and including Swaledale.

How far the stream ultimately extended has not been definitely ascertained, but it certainly reached several miles beyond the city of York.

The excursions on the 26th and 27th April will be made to view two magnificent terminal moraines, the finest in the British Isles, which mark phases in the retreat, or possibly of the advance, of this glacier. They extend as perfect and nearly parallel crescentric mounds nearly from the foot of the Wolds round to the outcrop of the Magnesian Limestone.

York stands a little to the western side of the centre of the more northerly moraine, and on the first day's excursion the westerly limb will be visited. Sections are visible on the mount at York and in the neighbourhood of Bilbrough. They show, besides the more characteristic dirty, clayey, moraine-stuff, fairly clean, well-washed gravel, yielding characteristic erratics. Beyond Bilbrough where the side of the glacier seems to have received a check from a boss of

Bunter sandstone, a broad swampy breach occurs through which the stream flowing from Marston Moor makes its way, and beyond this, a series of parallel ridges, notably that upon which the village of Healaugh stands, may be seen, which are identifiable as the lateral moraines of the great glacier.

The return to York will be made through the villages of Askham Richard and Acomb, so that a fragmentary and confused terminal moraine may be seen which runs in rough parallelism to the York and Bilbrough moraine, and observations will be made of Askham Bog, an inter-morainic swamp, which is hemmed in between the two ridges.

The second day's excursion will be devoted to the eastern portion of the York moraine, passing through the villages of Grimston Smithy and Holtby. At the former place there is an exposure of gravelly moraine, where an ancient interment containing two human skeletons was discovered last Christmas ; at the latter place a magnificent railway section is seen cutting completely through the moraine, which there consists mainly of true boulder-clay, unstratified, and containing large numbers of well-scratched boulders. The excursion will be extended across the Derwent at Stamford Bridge to the outer (more southerly) moraine at High Catton, where excellent sections may be seen in a series of gravel pits.

Beyond High Catton shreds of other moraines may be traced near the edge of the Wold escarpment, but they are far less perfect than the two which I have called the York and Escrick moraines respectively.

In Memoriam.

RICHARD CARTER, C.E., J.P., F.G.S.

Mr. Carter was born on April 18th, 1818, at Prospect House, Harrogate, which stood on what is now the site of the Prospect Hotel. After being educated at Harrogate, he was articled to Mr. Bulmer, Surveyor and Civil Engineer, York. Shortly after this time he joined his brother in travelling in the United States, notably in Texas. Returning home in 1841, he commenced practice in Halifax as a Civil Engineer, and became engaged upon the surveying and laying out of various lines of railway, which have subsequently been incorporated in the Lancashire and Yorkshire system. At this period, for about five years, his staff included Mr. Tyndall, afterwards Professor Tyndall, the eminent Physicist.

About the year 1856 he removed to Barnsley, where he and his brother, Mr. Nicholas Carter, owned a large linen factory. This town proved the scene of Mr. Richard Carter's most active public life, and for more than twenty years he devoted great interest to its welfare and prosperity. He was a member of the Local Board of Health, and after the Charter of Incorporation was obtained he served the offices of Councillor, Alderman, and Mayor (two years). During this period his influence was paramount in connection with public works for the purposes of water supply and drainage of the Borough. The Messrs. Carter were, at this time, deeply interested in collieries, and Mr. Richard Carter devoted much time to geological questions and their technical applications.

In 1882 Mr. R. Carter joined his brothers and sisters in fixing upon Harrogate as their permanent residence, and the influence exerted by the family in developing extensive building schemes has very largely contributed to the present position of that flourishing watering place. The small syndicate which controlled the improvements, provided the commanding site occupied by the new railway

Very truly yours
Richd. Taylor

station, and laid out handsome avenues and streets. The safeguarding of the mineral springs, and the development of facilities for their use for drinking and bathing were objects which simultaneously received the anxious care of the new municipality. Even at the present time the change effected in Harrogate in less than twenty years has amounted to reconstruction.

Mr. Carter joined the Yorkshire (then West Riding) Geological Society in 1848. The Proceedings record that in 1855 he read a paper on a new Boring Machine for Artesian Wells and other purposes. In July, 1857, he gave a valuable paper on the subject of Colliery Ventilation, and as this occurred very shortly after the explosion at the Lund Hill Colliery, which destroyed nearly 200 lives, it excited much interest and discussion. Mr. Carter showed how the necessities for ventilation had grown with the ever-increasing depths at which coal is wrought, and propounded a scheme which was supported by other practical men. At a Meeting held in 1860, he again brought the matter before the Society, and claimed that the principle of direct ascending ventilation had justified the representations as to its perfect and economical applications which he had previously made. In April, 1884, the Society held its Meeting in Harrogate, Mr. Carter occupying the chair, and giving an interesting description of the geological and other features of the locality. Very hospitable entertainment was offered to the Society by the Messrs. Carter on this occasion. The Charter of Incorporation had been granted to the Borough in the preceding February, when Mr. Richard Carter acted as Returning Officer, his brother, Mr. Nicholas Carter, being elected as the first Mayor. In 1885, Mr. R. Carter was appointed a Justice of the Peace. As chairman of several public bodies, and a director of many more, he was a most useful citizen. In freemasonry he occupied a leading position. Mr. Carter represented the Yorkshire Geological Society on the Board of Governors of the Yorkshire College, and he was a member of the Coal Mining Committee of the latter Institution.

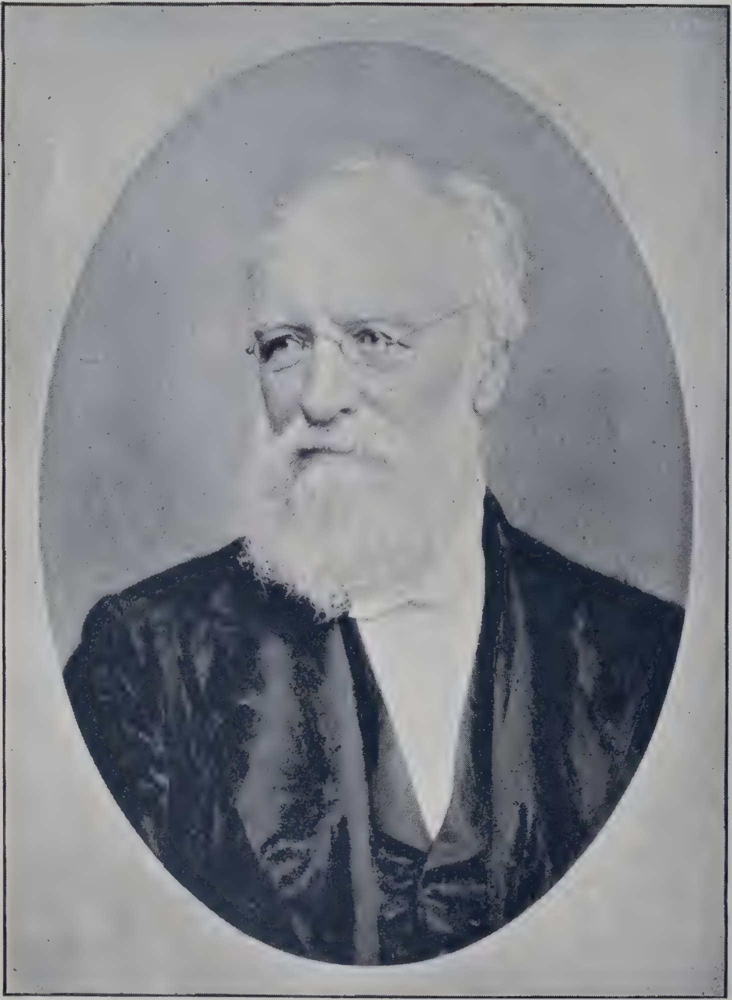
Mr. Carter's last illness was brief, and resulted from a severe chill contracted when he was inspecting the site of a new reservoir. On September 25th, 1895, he passed away, in his 78th year. The funeral, which took place at Christ Church, Harrogate, was very largely attended, and many public bodies were represented. Mr. Carter's connection with the Yorkshire Geological Society was of earlier date than that of any of the other important public bodies that have been mentioned, and he had so closely maintained his interest in the Society and a cordial friendship with his colleagues in its direction, that here he will be greatly missed and his loss will be long regretted.

At the Annual Meeting, held at Huddersfield, Nov. 13th, 1895, the following Resolutions were recorded on the motion of the Chairman (Mr. R. Reynolds), seconded by Mr. J. Stubbins :—

"That the Society expresses its sorrow at the removal by death "of one of its Vice-Presidents, Mr. Richard Carter, C.E., F.G.S. A "Member of the Society since 1848, and of the Council since 1854, "Mr. Carter has been constant in his support during this long "period. His zeal for geology, combined with a mature experience "of the history of the Society for nearly half-a-century, and the "geniality of his friendships gave to Mr. Carter's influence an especial "value, and his loss is felt by his colleagues to be very great."

"That a copy of the foregoing Resolution be sent to Mr. "Nicholas Carter, J.P., with the condolence of the Society towards "Mr. Richard Carter's relatives under their bereavement."

R. R.



W. C. Williamson

In Memoriam.

WILLIAM CRAWFORD WILLIAMSON, LL.D., F.R.S., &c.

BORN 24th NOV. 1816. DIED 23rd JUNE, 1896.

The memoirs of the great Yorkshire Naturalist who passsd from us during the early summer of last year have appeared in several of the Scientific Journals, both at home and abroad, and have quite recently been so ably and fully set forth in "The Reminiscences of a Yorkshire Naturalist" that there remains little to add; but the Council of our Society, with whom Professor Williamson was connected as a highly valued honorary member, deem it fitting that the pages of its Proceedings should contain some record of his career, and bear testimony to the value of his numerous scientific labours which extended over the long period of sixty years.

The subject of our story was a native of Scarborough, where he was born on the 24th November, 1816; his father, John Williamson, a gardener, and an ardent student of nature, came of a sturdy, self-reliant Yorkshire stock, and has been admirably portrayed by his son in a charming memoir in our Society's Proceedings for 1894; a perusal of this sketch reveals the source of that deep love of nature and fondness for scientific research which was undoubtedly inherited by the son from his father.

In 1824 John Williamson made the acquaintance of the father of English Geology, William Smith, well-known to his contemporaries as Strata Smith, and subsequently that of his nephew the late Professor John Philips; both these men were frequent visitors to Scarborough, and indeed the former for some considerable time was a resident in the Williamson's home, and so it came about that as boy and youth the budding geologist expanded in an atmosphere in every way congenial to the development of his scientific powers. By continuous contact with these and many other men of science who called upon his father he was placed in a favourable environment. His father was appointed Curator to the Scarborough Museum which lead to many and widespread explorations of the surrounding country in search of specimens ; plants, shells, insects, marine animals, birds abounded in the varied habitats of marsh, moor, wood and sandhills, among the rocky pools of the coast and in the inland ponds and rivers from which were drawn numerous treasures to enrich the beloved museum. In this way a real practical knowledge of natural history was acquired, which proved of great value in later years when the student became an author. Nor were these explorations limited to the living organisms ; perhaps there is no district in Britain more attractive to the geologist than the magnificent series of cliffs stretching from Flamborough in the south to Saltburn in the north, where are exposed the rich fossil treasures of the Secondary strata, ranging from the Chalk to the Upper Lias, to say nothing of the beds of boulder clay which cap them nor of the Tertiary beds exposed at their base near Bridlington. How delightful these excursions were we learn in "The Reminiscences," and the plentiful collections then made were afterwards utilised in many of his scientific papers ; these were days of preparation during which the seed was sown, later to burst into healthy shoot and foliage and the noble fruit of original research. All too soon these happy days sped by ; a short time at school in France ; a brief but memorable visit on his homeward journey to his father's geological friend, Sir Roderick Murchison, in London, and then it became necessary to face the problem of earning a more settled living than science, however delightful, could provide ; hence, we find him in 1832 apprenticing himself to Thomas Weddel, Surgeon, of Scarborough, with whom he remained until 1835.

Witham had just published his researches on the minute structure of Carboniferous plants by means of thin sections, whilst Lindley and Hutton's "Fossil Flora of Great Britain" appeared in 1837 : to the latter Williamson contributed many drawings by way of illustrations, and so quite early in life he began to study that department of Fossil Botany in which he afterwards became so distinguished. His first papers, however, written when only eighteen years of age, dealt with varied subjects, on the genus Mytilus, the Lias Fossils, and the Gristhorpe Tumulus.

In 1835 the Curatorship of the Manchester Museum was accepted by our Yorkshire Naturalist, who removed from the county of his birth to that of his adoption, and in Manchester he laboured for more than half a century, first as medical man then as professor of Natural History and Geology, then of Biology, and lastly of Botany at Owen's College, where his scientific fame increased until he became known as 'facile princeps' in his own special subject of Coal Measure Palæobotany, not only at home but abroad in Europe, America, our Colonies, and wherever this science is cultivated.

It was in 1842 that he began practice as a medical man in Manchester; for the following decade he appears to have studied and written upon a great variety of subjects, such as the Geological Strata of the Yorkshire Coast, the Rare Birds of Scarborough, the Limestones near Manchester, Fossil Fishes, Foraminifera, the Mud of the Levant, and the Origin of Coal; about this period he commenced to use the microscope largely, and acquired that skill which served him so well in his subsequent micro studies on the minute structures of fossil plants.

In 1851 he was elected Professor of Natural History and Geology at Owen's College.

In 1854 he was elected a Fellow of the Royal Society, and at his death was then one of its oldest Fellows. The fifties and sixties were years of active work; papers on scientific subjects followed each other in rapid succession, many public lectures were given and patient researches carried on. In 1858 his beautifully illustrated memoir on "The Recent Foraminifera of Great Britain" was issued by the Ray Society. In 1868 he published a paper on "The structure of the woody zone of an undescribed form of Calamite," the forerunner of a long series on the minute structure of the Coal Measure Plants, which found their fullest expression in his magnificent monographs "On the organization of the Fossil Plants of the Coal Measures," which appeared almost yearly in the Philosophical Transactions of the Royal Society, and indeed are a grand monument of his tireless zeal and consumate ability in the department of original palæobotanical research, and which are known and prized wherever fossil botany is studied.

In 1872 Professor Williamson was relieved from teaching geology on the appointment of Professor Boyd Dawkins on the staff of Owen's College, he was thus enabled to devote himself more fully to purely biological work.

We have already said that Williamson by heredity and by environment was highly favoured in his scientific career; he was equally fortunate in gathering around him a body of zealous and enthusiastic helpers from the practical field geologists of Lancashire and Yorkshire, who placed most liberally in his hands many hundreds of specimens collected by them in the coalfields of the two counties. Of these honourable mention must be made of John Butterworth, F.R.M.S., of Shaw, near Oldham, who was one of the first to prepare thin sections of fossil plants suitable for microscopic examination; Messrs. Nield, Whitaker, Isaac Earnshaw and George Wilde all rendered efficient aid, and in later years many valuable specimens were collected and prepared by James Lomax, who is well-known for the large sections made by him. If these Lancashire geologists vied with each other in searching for and sectionising material for study those of Yorkshire were not behindhand; many new and choice specimens reached the professor's cabinet by the self-denying and devoted labours of James Spencer and James Binns, of Halifax.

The present writer also had many opportunities of adding his mite to the great work, and has heard Professor Williamson express more than once his sense of indebtedness to those whom he was pleased in his humorous way to call his lieutenants, without whom he could scarcely have accomplished so much as he did. As a Gilchrist lecturer he came into contact with many working naturalists, and doubtless some of his helpers had their interest in fossil botany first excited on attending his lectures; the Professor's happy style of lecturing won the approval of the hard-headed and shrewd artisans of the northern towns, his mastery of the art of delineating with chalk on the black board, and his homely and clear language appealed to their love of facts and strong common sense. His influence was felt also in other directions as may be gathered from the following reminiscences for which I am indebted to Dr. H. C. Sorby, F.R.S., &c., who writes me, "I first made the acquaintance of Professor Williamson about forty-five years ago in a railway carriage, when we were both returning from Scarborough. I afterwards went to spend a day with him during a visit to my cousin, Mr. James Nasmyth, when he was practising as a surgeon in Manchester. He took me to the interesting deposits of limestone at Ardwick, and showed me the microscopical sections he had prepared of the teeth and scales of fossil fishes. He was then also preparing sections of fossil plants. I had never previously seen such sections, and on my return home I preprepared some myself, and was very soon led to extend the method to limestones, slates, and other rocks. He was thus largely instrumental in leading me to develop that subject, which has since grown to be so extensive. I think the next time we met was long after, when we were the recipients of the Royal Medals of the Royal Society."

Prior to 1870 Williamson's studies were many and varied ; rocks, plants, animals and even antiquities. All this work was, however, preparatory to his special researches on the minute structure of Fossil Coal Plants, to which the last twenty-five years of his life were devoted with ever-increasing success and clearer insight into the character of the ancient Flora, until he became the principal exponent of its phenomena to the whole scientific world.

The early seventies found him engaged in an investigation of the Cryptogamic Fruit-spikes of the Coal period. In 1876 he commenced a series of experiments and researches on the structure of the Coals of the world. He received for examination numerous specimens from the Coal-fields not only of Great Britain, but of New Zealand, Australia, South Africa, Japan, Borneo, Sweden, France, Germany, Belgium, India, the United States, Nova Scotia and the Arctic Regions ; unfortunately these researches were never completed.

The Royal Society in 1874 awarded to him its gold medal in recognition of its appreciation of his scientific discoveries.

In 1880 the appointment of Professor Milnes Marshall to the new Chair of Zoology at Owen's College enabled Williamson to concentrate his powers on Botanical subjects alone, to the advantage of his researches in Fossil Botany, as is seen in the increased value of his subsequent papers on the subject.

Edinburgh University conferred upon him the honorary degree of LL.D. in 1883, an example followed by the Royal Academy of Göttingen, who elected him an honorary member in 1885.

The last decade of his life was filled with useful scientific labour. Among many papers written during this period the Palæontographical Society's Monograph of the Morphology and Histology of Stigmaria ficoides, published in 1887, is perhaps the most important.

In 1890 the Geological Society of London awarded him the Wollaston Gold Medal.

On the resignation of his professorial chair at "Owens," Professor Williamson removed to London, where he at once made arrangements to conduct his researches with the assistance of the distinguished Botanist, Dr. Scott, F.R.S., and together they published, on the lines of modern Botany, several memoirs in the Philos. Transactions of the Royal Society.

The time for the cessation of all work drew on apace, and fertile brain and facile hand began to lose their cunning, until at last quietly and peacefully he fell asleep at his own house at Clapham Common, on the 23rd June, 1895.

His method of work is expressed in "The Reminiscences" as follows :—"I determined not to look at the writings of any other observer until I had studied every specimen in my cabinet, and arrived at my own conclusions as to what they taught. Having thus formed my own independent judgment, I then turned to the works of other writers on the same subjects to learn in detail what their views were."

Professor Williamson was very fortunate in his family life ; he was first married in 1842 to Miss Sophia Wood, the daughter of the Rev. Robert Wood, and afterwards in 1874 to Miss Annie Copley Heaton, the niece of Sir Henry Mitchell. He made the acquaintance of this lady when the guest of her uncle during the Bradford British Association Meeting in 1873. Those who have had the privilege of visiting the home of the Williamsons at Fallowfield, with its charming botanical garden, know how happy that union was, and that the peaceful calm and affection of that household were a great help to the Professor in his arduous studies. As a man he was genial, shrewd, observant, versatile, and of an untiring energy ; one of his memorialists compares (I think appropriately), his "transparent egotism" with that of the author of "The Autocrat of the Breakfast Table." He was a good typical Yorkshireman, and quite able to hold his own on all occasions.

He formed the finest collection in the world of microscopic sections of Coal Measure Plants, which is now in the possession of the British Museum. None are better acquainted with this collection than his friend Count Solms-Laubach, who, in his "Einleitung in die Palæophytologie," says that he soon realised that it was quite impossible to produce such a book without an accurate knowledge of Williamson's collection of sections.

I shall not attempt here any critical estimate of his scientific work. Something in that direction may be found in Nature, vol. 5, Sept., 1895, from the pen of Count Solms-Laubach.

That he was the great leader in Palæophytology of his age and shed a flood of light on its obscure problems is not questioned.

In the large Geological Room at Owens College, Manchester, may be seen an immense Stigmarian Root or Rhizome—surely a magnificent monument to Dr. Williamson.

The late Mr. J. W. Davis, F.G.S., &c., of Chevinedge, Halifax, has thus described his visit with Dr. Williamson to see this famous Stigmaria.

"On the morning we had arranged to see the Clayton tree rain poured in torrents, and I tried in vain to persuade Dr. Williamson to postpone his journey. At Halifax we left the main line for a local one. After travelling several miles up the line we went out into the rain, and proceeded to tramp along unprotected upland paths, or in sodden grass, through a perfect hurricane of wind ; before half the distance was accomplished our boots had become pools, and our clothes were saturated. When we reached the quarry not a living soul was near, only the grey sky above, grey Yorkshire hills around, and the storm raging, when the old geologist met face to face the thing he had hoped so long to see." As he stood and gazed at the calm big tree spreading its roots in every direction, the quarry master appeared, looking astonished, and said, "Not Professor Williamson!" "Certainly." "And from Manchester this morning," said the shivering owner. "Yes, and why not?" "Well sir," answered he, "to my thinking you and the tree are a pair for teaching us lessons."*

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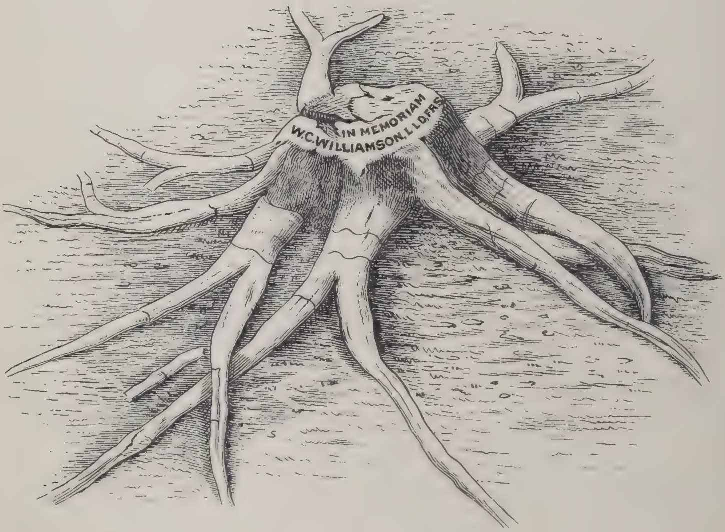
* Reminiscences of a Yorkshire Naturalist, note p. 186-7.



MEMOIRS AND PAPERS BY THE LATE DR. W. CRAWFORD WILLIAMSON, F.R.S., &c.

ON THE ORGANISATION OF THE FOSSIL PLANTS OF THE COAL MEASURES:

Pt. i. Calamites; Phil. Trans. 1871, p. 477, seq.

Pt. ii. Lycopodiaceæ, Lepidodendreæ and Sigillarieæ; Phil. Trans. 1871, p. 197, seq.

Pt. iii. Lycopodiaceæ (continued); Phil. Trans. 1872, p. 283, seq.

Pt. iv. Dictyoxylon, Lyginodendron, Heterangium; Phil. Trans. 1873, p. 377, seq.

Pt. v. Asterophyllites; Phil. Trans. 1873, p. 41, seq.

Pt. vi. Ferns; Phil. Trans. 1874, p. 675, seq.

Pt. vii. Myelopteris, Psaronius, Kaloxylon; Phil. Trans. 1876, p. 1, seq.

Pt. viii. Ferns, Gymnospermous Stems and Seeds; Phil. Trans. 1877, p. 213, seq.

Pt. ix. Phil. Trans. 1878, p .319, seq. (deals with Astromyelon, Calamites, Asterophyllites, Lepidodendron and Sigillaria, Lepidodendroid reproductive organs, Ferns, and Cordaites).

Pt. x. Including an examination of the supposed Radiolarians of the Carboniferous Rocks; Phil. Trans. 1880, p. 493, seq. (deals also with Ulodendron, Spores, Ferns, Conceptacles, and Calcisphœra).

Pt. xi. Phil. Trans. 1881, p. 283, seq. (deals with Lepidodendron, general conclusions respecting the Carboniferous Lycopods, Calamostachys Binneyana and C. Casheana).

Pt. xii. Phil. Trans. 1883, p. 459, seq. (deals with Myriophylloides Williamsonis, Psaronius Renaultii, Zygosporites, Calamites, Lepidodendroid plants, Halonia, Sporocarpon, and Dadoxylon).

Pt. xiii. Heterangium Tiliœoides, and Kaloxylon Hookeri; Phil. Trans. 1887, p. 289, seq.

Pt. xiv. The True Fructification of Calamites; Phil. Trans. 1887, p. 47, seq.

Pt. xv. Phil. Trans. 1888, p. 155, seq. (deals with Zygopteris, Anachoropteris, and Rhachiopteris).

Pt. xvi. Phil. Trans. 1889, p 193, seq. (deals with the development of the medulla in the centre of the axial vascular bundle, and with Rhachiopteris irregularis).

Pt. xvii. Phil. Trans. 1890, p. 89, seq. (deals with Lyginodendron Oldhamium and Rhachiopteris aspera, Bowmanites, and Calamites).

Pt xviii. Phil. Trans. 1891, p. 255, seq. (deals with Bowmanites Dawsoni and Rhachiopteris ramosa).

Pt. xix. Phil. Trans 1892, p. 1, seq. (deals with Lepidodendron Harcourtii, Lepidophloios, Lepidodendron Spenceri, and Lepidostrobus).

FURTHER OBSERVATIONS ON THE ORGANISATION OF THE FOSSIL PLANTS OF THE COAL MEASURES.

BY W. C. WILLIAMSON, LL.D., F.R.S., EMERITUS PROFESSOR OF BOTANY IN THE OWENS COLLEGE, MANCHESTER, AND D. H. SCOTT, M.A., PH.D., HONORARY KEEPER OF THE JODRELL LABORATORY, ROYAL GARDENS, KEW.

Phil. Trans. 1894, p. 863, seq. Pt. i. Calamites, Calamostachys, and Sphenophyllum. Pt. ii. The Roots of Calamites, 1894. Pt. iii. On Lyginodendron and Heterangium, 1895.

MEMOIRS AND PAPERS BY W. C. WILLIAMSON, LL.D., F.R.S.

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SECRETARY'S REPORT FOR 1895.

During the past twelve months the Society has maintained the high level both of its meetings and publications, and the attendance at the meetings has been so satisfactory as to justify the conviction that the Society is in a thoroughly healthy and active condition. The Spring General Meeting was held at York on April 26th and 27th, and was associated with excursions to view the remains of two glacial moraines in the neighbourhood. An interesting feature of this meeting was the company of several members of the Glacialists' Association who had accepted the Council's invitation to join the party. On Friday, April 26th, the members met at York Station, and the party, numbering 25, was conveyed by waggonette to Ascham Bryan, where a section in the York, or more northerly, moraine was examined. The journey was resumed to Bilbrough Hall, which was shown to the party by the kindness of Guy T. Fairfax, Esq., and the curiosities and relics of the Fairfax family, and especially of General Lord Fairfax, were described by Commander Markham. Before leaving a cordial vote of thanks was passed to Mr. Fairfax and Commander Markham for their kindness. The return journey was by Healaugh and Acomb, giving good views of the rounded contours of the York moraine. The General Meeting was held at the Museum of the York Philosophical Society, Sir Charles Strickland, Bart., presiding. Interesting papers were read by Mr. Thos. Sheppard, of Hull, on "Another section in the so-called glacial gravels of Holderness," and by Mr. C. Fox-Strangways, F.G.S., of the Geological Survey of England, on "Glacial Phenomena near York." Mr. Percy F. Kendall, F.G.S., gave an interesting address on "Additional facts respecting the Glacial Phenomena of Yorkshire," illustrated by a large map of the York moraines. The members dined together at the North Eastern Hotel, under the presidency of Rev. E. Maule Cole, M.A., F.G.S., in the unavoidable absence of Sir Chas. Strickland. In addition to the usual loyal toast, the toasts of the Lord Mayor, Sheriff and Corporation of York, responded to by the Sheriff, Dr. Tempest Anderson, the Yorkshire Philosophical Society, the Glacialists' Association, and the Yorkshire Geological and Polytechnic Society were proposed. After dinner the Meeting was resumed in the Coffee Room of the North Eastern Hotel, under the presidency of Rev. E. Maule Cole. Mr. J. Spink, of Pickering, exhibited, on behalf of Major Jas. Mitchelson, a collection of animal remains and pottery found in a lake-dwelling at Pickering, and gave an account of the discovery of the "finds." Mr. P. F. Kendall, F.G.S., exhibited a series of lantern slides, kindly lent by Dr. Wright, to illustrate features of American glacial geology, and especially dealing with the great Muir Glacier of Alaska.

On Saturday, April 27th, the party proceeded by train to Holtby, where a careful examination of a cutting in the North-Eastern and Midland Railway was made. This cutting passes transversely through the northern, or York, moraine, and shows a good section of boulder-clay, in which the members found Shap granite, Scottish granites, Brockram, Carboniferous rocks, and Trias marls with pseudomorphs of rock salt and gypsum. The road was then taken to Stamford Bridge, where a short halt was made for lunch. High Carlton was the next locality visited. Here a gravel pit in the southerly, or Escrick, moraine was examined. It showed beds of coarse and fine gravel and sand, containing Brockram and Carboniferous rocks. The ridge was then ascended and a good view obtained of the lie of the two crescentic moraines. On the return journey the southerly moraine was crossed again, showing gravelly deposits in the middle and boulder-clay, with a little sand, plastering the flanks of the moraine. A little further on chalky gravels were found in a field near the High Catton Railway Bridge. The party returned to York by waggonette from Stamford Bridge, and dined together at the North Eastern Hotel. Before dinner there was a meeting of the Glacialists' Association, at which the members of the Yorkshire Geological Society were present by invitation. An interesting paper on "The Glaciation of the Færoes," by Dr. Karl Grossman and J. Lomas, A.R.C.S., was read by Dr. Grossman, and illustrated by a remarkable series of lantern slides taken during their journey.

The Summer General Meeting and Field Excursion of the Society was held at Filey, on Thursday and Friday, June 27th and 28th. On Thursday the members attempted to carry out the programme, which included the examination of the coast from Filey Brigg to Gristhorpe Bay, but a heavy thunderstorm which broke over Filey about noon rendered this almost impossible, and interfered much with the comfort of the members. Most of the time not spent under shelter was devoted to the examination of the Brigg, but an enterprising party, under the leadership of Mr. J. W. Stather, F.G.S., succeeded in getting as far as Gristhorpe Bay. On Friday, June 28th, the party proceeded along the shore from Filey to Speeton, examining the drift deposits and also the Neocomian beds and the Lower Chalk. After ascending Speeton Gap and inspecting the moraine on the summit of the cliff, the party returned to Filey by train. In the evening the members dined together at the Crescent Hotel, Filey, under the presidency of R. H. Tiddeman, Esq., M.A., F.G.S., of the Geological Survey of England. After dinner the General Meeting was held which was of a conversational character, various points of interest in the geology of the district being touched upon by the Chairman, Messrs. Stather, Mortimer, Walton, and Carter.

On Saturday, June 29th, the members joined the Yorkshire Naturalists' Union Excursion to Flamborough. The route taken was from Bempton Station to the cliffs, and along the cliff path to North Landing and the Lighthouse. The chief points of interest were the fine contortions at Old Dor and the antics of the guillemots and other sea birds, the splendid examples of marine denudation at Thornwick Bay and North Landing, and the interesting blow-hole, and glacial beds under the Lighthouse.

Early in the year a fine photograph of the denuded boulder-clay of Carr Naze, Filey, from a negative kindly lent by Mr. Godfrey Bingley, of Leeds, was issued to the members, together with a description of the locality by Rev. E. Maule Cole, M.A., F.G.S. Vol. xii. part v. of our Proceedings also issued during the summer, and was illustrated by an unusually large number of excellent plates. In the opinion of the Council it will be advantageous to concentrate the efforts of the Society more especially on the Proceedings, and they believe that the members would prefer additional photographs to be issued in each volume of the Proceedings, rather than to have so much money spent yearly over one enlargement. In order to test this feeling the Council have resolved to issue with the Proceedings, vol. xiii., pt. i., a fine series of nine views of the Dry Valley of the Aire, above Malham Cove, which have generously been placed at the disposal of the Society by Mr. Godfrey Bingley. If this experiment is approved of by the members the Council will consider the advisability of continuing to issue series of views of geological interest year by year, with explanatory notes, to be bound up with the current volume of the Society's Proceedings.

Owing to the removal of Mr. Ernest E. Speight, B.A., from Yorkshire to Oxford, the work of exploration in Upper Wharfedale has had to be discontinued for the present. Three trustees, Messrs. J. R. Eddy, J. J. Wilkinson, and E. T. Hartley, were appointed by your Council to take charge of the "finds," but there was considerable difficulty in arranging for their safe custody. Mr. Eddy kindly provided a home for the "finds" in an empty cottage on the completion of the term of tenancy of Mr. Baxendale's cottage, in which they had been left by Mr. Speight, but the reports of the trustees and others convinced the Council that immediate steps should be taken to place them in some safe and suitable place. The Secretary was, accordingly, instructed to call a joint meeting of your Council and the Upper Wharfedale Exploration Committee at Grassington when the whole subject could be carefully considered on the spot. In accordance with this resolution the members of the two Committees were summoned to meet at Grassington on Saturday, October 19th. The morning was spent in an examination of the "finds," and in a survey of the sites of exploration. The members of the Committees were accompanied by Messrs. Crowther, Hill, and Rogers, of Grassington. The Joint Committee then met the Committee of the Grassington Mechanics' Institute, and conferred with them as to the most suitable location of the "finds." After some conference it was unanimously resolved that the results of the excavations undertaken by Rev. Bailey J. Harker and Mr. Ernest E.

Speight should be amalgamated, and placed in locked cases belonging to the Yorkshire Geological Society, under the complete control of trustees appointed by this Society. A suitable room was found in the Grassington Mechanics' Institute for the location of the cases, and your Council have pleasure in reporting that they consider that the safety of this interesting collection is now assured, and a proper basis established for future exploration work. Owing to the difficulty of adequate superintendence it is not proposed to proceed with the exploration any further at present, but steps will be taken to have a preliminary survey of several interesting parts of Grassington Moor made, with the view of ascertaining the exact plan of the complicated mounds existing there, and of determining the best localities for future operations.

Steps have been taken by your Council during the year for the location of the Library of the Society in some central place easy of access. Overtures were made to the Leeds Philosophical and Literary Society for the use of a cupboard in their library, in which the books owned by this Society could be deposited on loan. That application has been considered and agreed to by the Leeds Philosophical Society, and this forms another link in the bond of union which has for so many years united the two Societies together.

The Council much regret to have to record the loss by death of one of our Honorary Members, Professor Williamson, F.R.S., and also of the loss of two of the Vice-Presidents, Messrs. Richard Carter, J.P., F.G.S., and Thomas W. Tew, J.P., who took a great interest in the work of our Society. Mr. Carter, as a member of the Council for many years, was especially active in forwarding the interests of the Society, and the loss of his genial presence and weighty influence will be regretfully felt by his fellow-workers.

The officers are glad to be able to report that the Society is in a thoroughly sound financial position, and that the promises of papers and other scientific help give strong grounds for the hope that the next year of the Society's work will be quite as succesful as any previous year in its history.

The Proceedings of the Society have been forwarded, as in previous years, to leading Scientific Societies in various parts of the world, and the best thanks of the Society are due, and are hereby tendered, to the following Societies who have kindly sent their publications in exchange :—

Manchester Geological Society.
Royal Institution of Cornwall.
Academy of Natural Sciences, Philadelphia, U.S.A.
Societé Imperiale des Naturalistes, Moscow.
United States Geological Survey.
Boston Society of Natural History, U.S.A.
Hull Literary and Philosophical Society.
Academy of Sciences, St. Louis, Mo., N.S.A.
Geological Society of London.
Royal Geological Society of Cornwall.
Royal Physical Society of Edinburgh.
Museum of Comparative Zoology at Harvard College.
Bristol Naturalists' Society.
American Philosophical Society, Philadelphia.
Smithsonian Institution, Washington.
American Museum of Natural History, New York.
Leeds Literary and Philosophical Society.
University Library, Cambridge.
Manchester Geographical Society.
Yorkshire Philosophical Society, York.
Manchester Literary and Philosophical Society.
New York State Library, Albany.
L'Academie Royale Suedoise des Sciences, Stockholm.
Liverpool Geological Association.
Geological Institution, Royal University Library, Upsala.
Societé d'Emulation d'Abbeville.
United States National Museum, Washington, D.C.
New York Academy of Sciences.
Hull Geological Society.
Leeds Geological Association.
Nova Scotian Institute of Science, Halifax.
Geological Survey of Minnesota, Minneapolis.
Kaiserliche Leopoldinisch-Carolinische Deutsche Akademie der Naturforscher, Halle-a-Saale.
Royal Society of New South Wales, Sydney.
Wagner Free Institute of Science, Philadelphia.
Instituto Geologico de Mexico.
British Museum (Natural History).
Australian Museum, Sydney.
The Glacialists' Association.
The Department of Mines, Sydney, N.S.W.
The Geologists' Association, London.

RECORDS OF MEETINGS.

Council Meeting, Philosophical Hall, Leeds, 21st February, 1895.

The chair was taken by Mr. Richard Reynolds, F.C.S.

Present :—Messrs. T. Tate, C. W. Fennell, J. J. Wilkinson, J. Stubbins, J. E. Bedford, P. F. Kendall, W. Cash, W. Simpson, R. Carter, W. Rowley, and W. L. Carter (Hon. Sec.)

A letter of regret for absence was read from Mr. J. T. Atkinson.

The minutes of the preceding Council Meeting were read and confirmed.

Resolved that a Geological Photograph be published and issued to the members.

Mr. J. E. Bedford, F.G.S., exhibited a large number of fine Geological Photographs from negatives taken by Mr. Godfrey Bingley, of Leeds.

A small selection of Yorkshire Views having been made, it was resolved that a view of the old river valley of the Aire between Malham Tarn and Malham Cove be published. The next view on the list of selection was one of denuded Boulder-clay Cliffs, at Carr Naze, Filey. A fine photograph of Malham Cove was much admired. Mr. P. F. Kendall, F.G.S., suggested that a view should be taken of Speeton Windmill from near the Station to show the great moraine.

A vote of thanks was passed to Mr. Godfrey Bingley for affording the Council so choice a selection of photographs, and also for his kindness in offering the use of his negative for the production of a large photograph.

Mr. H. M. Platnauer, B.Sc., F.G.S., was appointed Local Secretary for the York District.

The Secretary reported that he had received a suggestion that the next General Meeting should be held at York, and that it should be associated with a Field Excursion for the examination of the York moraines described in Mr. Kendall's paper in the Proceedings, vol. xii., part iv.

Mr. Kendall explained his views for the programme of such a meeting.

It was then resolved that the next General Meeting be arranged as above, and that a cordial invitation be given to the members of the Glacialists' Association to join in the Meeting and Excursion.

The arrangements for the meeting were then discussed and a provisional programme adopted, Mr. P. F. Kendall, F.G.S , being appointed Leader.

With regard to the Upper Wharfedale Exploration Committee, the Hon. Secretary read letters from Mr. E. E. Speight stating that the tenancy of the cottage at Grassington expired on January 26th, and that Mr. Baxendale desired the removal of the "finds."

Mr. J. J. Wilkinson gave a short account of the negotiations with the authorities of the Grassington Mechanics' Institute, which seemed to have issued in a deadlock.

The Secretary reported that the Exploration Committee had met and requested the trustees to take steps for the security of the "finds." He was requested to communicate at once with Mr. J. R. Eddy.

General Meeting and Excursion, held at York, April 26th and 27th, 1895.

Friday, April 26th. The members met at York Station at 12-15. A waggonette conveyed the party, which numbered twenty-five, to Ascham Bryan, where a section in the northern, or York, moraine was examined.

The journey was resumed to Bilbrough Hall which was shown to the party by the kindness of Guy T. Fairfax, Esq., and the relics of the Fairfax family, and especially of General Lord Fairfax, were described by Commander Markham. Before leaving a very cordial vote of thanks was passed to Mr. Fairfax for his kindness in exhibiting this interesting collection, and to Commander Markham for his lucid explanations.

The return journey was by Healaugh and Acomb, giving good views of the York moraine.

The *General Meeting* was held at the York Museum, at 4-30, by the kind permission of the Yorkshire Philosophical Society.

The chair was taken by Sir Chas. Strickland, Bart.

Present :—41.

The following new members were elected :—

John Farrah, F.R.Met.S., Harrogate.
Alfred Harker, M.A., F.G.S., Cambridge.

A Paper was read by Mr. Thomas Sheppard, on "Another section in the so-called Interglacial Gravels of Holderness," illustrated by a section.

A Paper was communicated by Mr. C. Fox-Strangways, F.G.S., of the Geological Survey, on "Glacial Phenomena near York," illustrated by a sketch map.

An Address was delivered by Mr. P. F. Kendall, F.G.S., on "Additional Facts respecting the Glacial Phenomena of Yorkshire," illustrated by a large map of the York moraines.

A vote of thanks was passed to Sir Chas. Strickland for presiding.

The members dined together at Halliwell's North Eastern Hotel, under the presidency of the Rev. E. Maule Cole, M.A., F.G.S., in the unavoidable absence of Sir Chas. Strickland, Bart.

In addition to the usual loyal toast the following toasts were proposed from the chair :—

The Lord Mayor, Sheriff, and Corporation of York ; responded to by the Sheriff, Dr. Tempest Anderson.

The Yorkshire Philosophical Society ; responded to by Mr. J. E. Clark, B.A., B.Sc.

The Glacialists' Association ; responded to by Dr. Karl Grossmann.

The Yorkshire Geological and Polytechnic Society ; responded to by the Hon. Secretary.

After dinner the meeting was resumed in the Coffee Room of the North Eastern Hotel, under the presidency of the Rev. E. Maule Cole.

Mr. J. Spink, of Pickering, exhibited, on behalf of Major James Mitchelson, a collection of pottery and animal remains found in a Lake-dwelling near Pickering, and gave an account of the excavations that had been made.

Mr. P. F. Kendall, F.G.S., exhibited a fine series of Lantern Slides, kindly lent by Dr. Wright, to illustrate glacial features in the extreme north-west of America, and especially features exhibited by the great Muir Glacier, of Alaska.

A discussion followed on the various papers and addresses in which Dr. F. F. Walton, Mr. J. E. Clark, Rev. E. Maule Cole, and Mr. P. F. Kendall took part.

A vote of thanks was passed to the Yorkshire Philosophical Society for kindly granting the use of the Museum, and to Mr. H. Platnauer for his arrangements for the meeting.

Saturday, April 27th. The party proceeded by train to Holtby, where a careful examination was made of a cutting in the North-Eastern Railway. This cutting passes transversely through the northern moraine and showed a good section of boulder-clay, in which were found boulders of Shap granite, Scottish granites, Brockram, Carboniferous rocks, and Trias marls with pseudomorphs of rocksalt and gypsum. The road was then taken to Stamford Bridge where a short halt was made for luncheon. Thence the party proceeded to High Catton where a gravel-pit in the southern, or Escrick, moraine was examined. It showed beds of coarse and fine gravel and sand containing Brockram and Carboniferous rocks. The Escrick moraine was then ascended and a good view obtained of the lie of the two moraines. On the return journey the southern moraine was crossed again showing a section of gravelly deposits in the middle, and boulder-clay with a little sand plastering the outer side of the moraine. A little further on chalky gravels were seen in a pit near the railway bridge at Hunger Hill. The party returned by waggonette from Stamford Bridge to York, and dined together at the North Eastern Hotel. Before dinner a meeting of the Glacialists' Association was held, to which the members of the Yorkshire Geological Society were courteously invited. An interesting paper on "The Glaciation of the Faroes" by Dr. Karl Grossmann and Mr. J. Lomas, A.R.C.S., was read.

Council Meeting, Philosophical Hall, Leeds, 10th June, 1895. The chair was taken by Mr. Richard Reynolds, F.C.S.

Present :—Messrs. R. Carter, W. Cash, P. F. Kendall, J. T. Atkinson, J. J. Wilkinson, C. W. Fennell. J. H. Howarth, and W. L. Carter (Hon. Sec.)

The minutes of the previous Council Meeting were read and confirmed.

Letters of regret for non-attendance were read from Messrs. A. Lupton and J. R. Eddy.

Wharfedale Exploration. A letter was read from Mr. J. R. Eddy reporting that the "finds" had been removed from Mr. Baxendale's cottage to an unoccupied cottage belonging to Mr. Eddy. Mr. Wilkinson reported on a claim by Mr. Baxendale for £2 for rent. He also reported that owing to a burst in the water pipes the "finds" had become damaged by the wet. After some conversation it was agreed to leave the matter for the present in the hands of the trustees.

The Secretary reported that he had received a number of the Proceedings of scientific societies, sent in exchange, for which he had not house room, and suggested that it was desirable that arrangements should be made for their deposit in a central library.

Resolved that Messrs. J. T. Atkinson, R. Reynolds, and the Hon. Secretary be a Sub-Committee to interview the Council of the Leeds Philosophical Society as to the possibility of their being able to find room for the Library of the Society, and as to the conditions of its custody.

The following accounts were passed for payment :—

	£	s.	d.
Whitley and Booth (Proceedings) - -	24	5	4
Upfield, Green and Co. (Plates) - -	6	15	0
F. Carter (Circulars and Stationery) - -	2	0	0

Resolved that the Summer Meeting and Excursion be held at Filey, on June 27th and 28th, and that arrangements be made for the members to join the Yorkshire Naturalists' Excursion at Flamborough on Saturday, June 29th. The Secretary reported that Mr. R. H. Tiddeman, M.A., F.G.S., of the Geological Survey, had kindly promised to preside at the next meeting.

General Meeting and Field Excursion, at Filey, June 27th and 28th, 1895.

Thursday, June 27th. The route taken was from Filey across the bay to the Brigg, and then by the cliffs to Gristhorpe Bay. Most of the time was spent on the Brigg, a heavy thunderstorm interfering considerably with the comfort of the party. Mr. J. W. Stather, F.G.S., was the leader.

Friday, June 28th. The party proceeded along the shore from Filey to Speeton, examining the Drift deposits and the Neocomian and Lower Chalk strata. After ascending Speeton Gap and inspecting the moraine at the top of the cliff, the party returned to Filey by train.

The members dined together at the Crescent Hotel, Filey, under the presidency of R. H. Tiddeman, Esq., M.A., F.G.S.

After dinner the *General Meeting* was held. The meeting was largely conversational, remarks on various points of interest in connection with the geology of the district being offered by the chairman (R. H. Tiddeman, Esq.), and Messrs. J. W. Stather, J. R. Mortimer, F. F. Walton, and W. L. Carter.

Mr. John Imbery, of Halifax, was elected a member of the Society.

A vote of thanks to the president of the day concluded the proceedings.

On Saturday, June 29th, the members joined the excursion of the Yorkshire Naturalists' Union to Flamborough. The route taken was from Bempton Station to the cliffs, and by the cliff path to North Landing and the Lighthouse. The leaders of the geological section were Messrs. J. W. Stather, F.G.S., and W. L. Carter, F.G.S.

Council Meeting, Philosophical Hall, Leeds, 17th September, 1895.

The chair was taken by Mr. Richard Reynolds, F.C.S.

Present :—Messrs. G. H. Parke, J. H. Howarth, J. J. Wilkinson, J. Stubbins, and W. L. Carter (Hon. Sec.)

Letters of regret for non-attendance were received from Messrs. W. Simpson, W. Gregson, C. W. Fennell, J. R. Eddy and T. Tate.

The minutes of the previous Council Meeting were read and confirmed.

Wharfedale Exploration. The Secretary read a letter from Mr. Cudworth saying that the "finds" were in a cottage at Grassington, in a very unsatisfactory condition. This statement was confirmed by Mr. Wilkinson and Mr. Stubbins. The Secretary was instructed to write to Mr. J. R. Eddy asking him to fix a date for a Council Meeting either at Grassington or Leeds, when the whole matter could be considered, and the future work of the Exploration Committee be decided upon. It was suggested that, if the meeting were held at Grassington, the Upper Wharfedale Exploration Committee should be summoned at the same time.

Resolved that the Annual Meeting be held at Huddersfield in November.

Resolved that Mr. Cash prepare a resolution in memory of the late Dr. Williamson.

Resolved that Mr. Thos. Hick, B.Sc., A.L.S., be nominated for Honorary Membership.

The Secretary exhibited a series of photographs taken by Mr. Godfrey Bingley, of the Dry Valley of the Aire, above Malham Cove.

Resolved that a series of these photographs be issued with the next part of the Proceedings, in place of a large photograph for 1896.

In conversation it was suggested that this might be an advisable precedent for the future, as the photographs would thus be more easily preserved, and there would be a considerable saving in the expenses of packing and postage.

The Secretary reported that he had had an interview with Mrs. J. W. Davis, and inspected the books belonging to the Society. He had arranged for their removal from Chevinedge when the Council provided a suitable location for the library. Mr. Reynolds reported that he had not yet been able to bring the matter before the Council of the Leeds Philosophical Society, but would do so at an early opportunity.

The following accounts were passed for payment :—

	£	s.	d.
Autotype Co. - - - - - -	33	12	3
Whitley and Booth - - - - -	41	16	0

The Secretary reported that he had received the Bond for £350 from the Town Clerk of Halifax, with coupons attached, and asked the Council to decide as to its custody. It was unanimously resolved that the Bond should be deposited with the Bankers of the Society, who should be requested to credit the coupons to the Society's account as they fell due.

Joint Meeting of the Council of the Yorkshire Geological and Polytechnic Society and the Upper Wharfedale Exploration Committee, at Grassington, October 19th, 1895.

The morning was spent in an inspection of the "finds," and a survey of the points on Grassington Moor, Conistone Old Pasture, and Grasswood, where the various excavations had been made.

In the afternoon there was a meeting of the Joint Committee and the Committee of the Grassington Mechanics' Institute, at the Mechanics' Institute, Grassington.

The chair was taken by Mr. J. R. Eddy, F.G.S.

Present :—Messrs. J. H. Howarth, J. Stubbins, J. J. Wilkinson, C. W. Fennell, W. Cash, E. T. Hartley, and W. L. Carter (Hon. Sec.), and Messrs. Joseph Longstaff, George Owram, and Thomas Platts, of the Grassington Institute Committee.

The Chairman opened the meeting by a statement of the present situation, and reviewed the negotiations which had taken place between the Exploration Committee and the Mechanics' Committee.

After some conversation the following resolutions were proposed by Mr. Thos. Platts, seconded by Mr. Jos. Longstaff, and carried unanimously.

Resolved—

(1) That the "finds" collected by the Rev. B. J. Harker and Mr. E. E. Speight be amalgamated.

(2) That the whole control of these "finds" be vested in Trustees appointed by the Yorkshire Geological and Polytechnic Society, and that these Trustees hold the keys of the cases.

(3) That the Grassington Mechanics' Institute agree to provide proper accommodation for the locked cases containing the "finds," and provide for their future safety.

The members of the three Committees then inspected the rooms in the Mechanics' Institute, and decided that the ante-room upstairs was a very suitable place for the location of the cases.

Council Meeting, George Hotel, Huddersfield, 13th November, 1895.

The chair was taken by Mr. Richard Reynolds, F.C.S.

Present :—Messrs. W. Cash, C. W. Fennell, G. H. Parke, J. Stubbins, J. Field, J. W. Stather, and W. L. Carter (Hon. Sec.)

The minutes of the previous Council Meeting and of the meeting of the Joint Committees at Grassington were read and confirmed.

Letters of regret for non-attendance were read from Lord Ripon, Messrs. J. T. Atkinson and W. Gregson.

The following accounts were passed for payment :—

	£	s.	d.
F. Carter (Circulars and Stationery) - -	4	15	7
J. Baxendale (Rent of Cottage at Grassington) on account of Exploration Committee -	2	0	0

The Chairman reported that the Council of the Leeds Literary and Philosophical Society had placed a Cupboard at the disposal of this Society for its Library.

The Secretary read the Annual Report and the Treasurer presented the Financial Statement, which were adopted for presentation to the Annual Meeting.

The list of officers was considered. Mr. J. R. Eddy was nominated as a Vice-President, in the place of the late Mr. R. Carter, F.G.S., and Dr. Forsyth, of Leeds, was nominated for a seat on the Council.

Mr. G. H. Parke, F.L.S., F.G.S., was appointed a Governor of the Yorkshire College for the year 1895-96.

Mr. William Cash, F.G.S., was appointed the representative of the Council on the Corresponding Committee of the British Association for the Liverpool Meeting of 1896.

The list of Local Secretaries was adopted without alteration.

Annual General Meeting, at Huddersfield, 13th November, 1895.

The chair was taken by Mr. Richard Reynolds, F.C.S., in the unavoidable absence of Mr. A. Smith Woodward, F.L.S., F.G.S.

Letters of regret for non-attendance were received from Lord Ripon, the Mayor of Huddersfield, Messrs. J. T. Atkinson, W. Gregson, J. Stears, G. W. Lamplugh, and F. W. Branson.

The Annual Report was read by the Hon. Secretary and adopted.

The Financial Statement was presented by the Treasurer and adopted.

The following new members were elected :—

Edward Tomson Hartley, M.A., Skipton.
Harry Muller, London.
Frank Wood, C.E., Wakefield.
Ernest Haworth, Wakefield.
Godfrey Bingley, Leeds.

Resolved and carried unanimously that Mr. Thomas Hick, B.A., B.Sc., A.L.S., of Owens College, Manchester, be elected an Honorary Member of the Society.

The officers were then elected as follows :—

President : The Marquis of Ripon, K.G.

Vice-Presidents :

Earl Fitzwilliam.
Earl of Wharncliffe.
Earl of Crewe.
Viscount Halifax.
Dr. H. C. Sorby, F.R.S., F.G.S.,
Walter Morrison, M.P.
W. T. W. S. Stanhope, J.P.
James Booth, J.P., F.G.S.
Dr. F. H. Bowman, F.R.S.E.
Prof. A. H. Green, F.R.S., F.G.S.
W. H. Hudleston, F.R.S., F.G.S.
Richard Reynolds, F.C.S.
J. Ray Eddy, F.G.S.

Hon. Treasurer : William Cash, F.G.S.

Hon. Secretary : W. Lower Carter, M.A., F.G.S.

Auditor : George Patchett, junior.

Council :

J. T. Atkinson, F.G.S.
J. E. Bedford, F.G.S.
J. Ray Eddy, F.G.S.
P. F. Kendall, F.G.S.
A. E. Preston, F.G.S.
Richard Reynolds, F.C.S.
Walter Rowley, F.G.S.
John Stubbins, F.G.S.

Prof. A. Lupton, F.G.S — Thos. Tate, F.G.S.
G. H. Parke, F.G.S., F.L.S. — David Forsyth, D.Sc., M.A.

Local Secretaries :

Barnsley - - -	T. W. H. Mitchell.
Bradford - - -	J. E. Wilson.
Driffield - - -	Rev. E. Maule Cole, M.A., F.G.S.
Halifax - - -	W. Simpson, F.G.S.
Harrogate - - -	R. Peach.
Hull - - -	J. W. Stather, F.G.S.
Huddersfield - -	Jos. Field.
Leeds - - -	J. H. Howarth, F.G.S.
Skipton - - -	J. J. Wilkinson.
Thirsk - - -	W. Gregson, F.G.S.
Wakefield - - -	C. W. Fennell, F.G.S.
Wensleydale - -	W. Horne, F.G.S.
York - - -	H. M. Platnauer, B.Sc., F.G.S.

The following resolution of regret at the decease of Professor Williamson, F.R.S., was moved by Mr. W. Cash, F.G.S., seconded by Mr. T. Hick, A.L.S., and carried :—

"The Council and Members of the Yorkshire Geological and Polytechnic Society desire to express their deep sympathy with Mrs. Crawford Williamson and Family on the death of Dr. Wm. Crawford Williamson, F.R.S., as well as their own sense of severe loss in this the first gap which has occurred in their list of Honorary Members. Dr. Williamson during a long and honourable scientific career of considerably more than half a century, devoted to many departments of Natural Science, and especially to the study of Fossil Botany, won for himself a scientific position and name known and valued both at home and abroad ; on the Continent of Europe, in our Colonies, and in the United States of America. His magnificent and original series of Memoirs on the Carboniferous Flora, which adorn the Transactions of the Royal Society, mark the climax of his powers, and will ever remain a monument of scientific industry and ability, and indeed may be regarded as the pioneer of the new methods which have placed the science of Palæobotany on a certain and true scientific basis. The loss of the kindly, genial personality of Dr. Williamson will be long and keenly felt in the social and scientific circles which he so lately adorned."

The following resolution of regret at the decease of Mr. Richard Carter, F.G.S, was moved by Mr. R. Reynolds, F.C.S., seconded by Mr. J. Stubbins, F.G.S., and carried :—

"That this Society expresses its sorrow at the removal by death of one of its Vice-Presidents, and a member of Council, Mr. Richard Carter, C.E., F.G.S. A member of the Society since 1848, and of the Council since 1884, Mr. Carter has been constant in his support during this long period. His zeal for geology, combined with a mature experience of the history of the Society for nearly half a century, and the geniality of his friendship gave to Mr. Carter's influence an especial value, and his loss is felt by his colleagues to be very great."

The following papers were then read :—

"A Memoir on the Fishes of the Upper Lias of Whitby." Part I., by Arthur Smith Woodward, F.L.S., F.G.S., of the British Museum (Natural History).

"On some Recent Advances in Palæobotany," by Thomas Hick, B.A., B.Sc., A.L.S., of Owens College, Manchester.

"Notes on the White Chalk of Yorkshire. Part I. : Its Thickness and small Faults," by G. W. Lamplugh, F.G.S., of the Geological Survey of England.

"Some Recent Observations on Alpine Glaciers," by Percy F. Kendall, F.G.S., of the Yorkshire College, Leeds. [Illustrated by a series of new Lantern Slides.]

"Notes on the Malham Dry Valley," by Thos. Tate, F.G.S.

"Notes on a Coin found in Grasswood," by William Fennell.

"Notes on a Well-boring at Ganstead, near Hull," by John Stears.

Votes of thanks to the Chairman for presiding, to the Governors of the Technical College, Huddersfield, for the use of the Hall, and to Mr. Thorp, the Secretary of the College, for his important assistance in making the arrangements, were passed unanimously.

The members dined together at the George Hotel, under the presidency of Arthur Smith Woodward, Esq., F.L.S., F.G.S.

Statement of Receipts and Expenditure of t

from 31st October, 189

Receipts.

REVENU

	£	s.
To Balance in hand, 31st October, 1894	29	15
,, Transfer from Capital Account	12	0
,, Subscriptions	105	5
,, Halifax Corporation—Interest	10	12
	£157	13

CAPIT

	£	s.
To Balance, 31st October, 1894	5	2
,, Life Members' Composition	12	12
	£17	14
To Balance	5	14
,, Halifax Corporation Bond	350	0
Capital	£355	14

WHARFEDAL

	£	s.
To Balance, 31st October, 1894	12	2
,, Interest	0	0
	£12	3

IEET.

orkshire Geological and Polytechnic Society.

31st October, 1895.

CCOUNT. Expenditure.

	£	s.	d.
y Whitley and Booth	64	5	4
,, The Autotype Co.	33	12	3
,, Upfield Green and Co.	6	15	0
,, Postages, Expenses of Meetings, &c.	18	15	7
,, Printing and Stationery	15	2	3
,, Books bought	2	11	6
,, Balance in Treasurer's hands, 31st October, 1895 ...	16	11	3
	£157	13	2

CCOUNT.

	£	s.	d.
y Transfer to Revenue Account	12	0	0
,, Balance	5	14	4
	£17	14	4

XPLORATION ACCOUNT.

	£	s.	d.
y Cost of Explorations, &c.	11	5	0
,, Balance in Treasurer's hands, 31st October, 1895 ...	0	18	4
	£12	3	4

Audited and found correct,

GEO. PATCHETT.

LIST OF THE BACK NUMBERS

STILL IN HAND

OF THE

PROCEEDINGS

OF THE

Yorkshire Geological and Polytechnic Society.

Volume	I.,	Part	IV.,	1840.	Volume	VI.,	Part	IV.,	1877.
,,	II.,	,,	I.,	1842.	,,	VII.,	,,	I.,	1878.
,,	II.,	,,	II.,	1843.	,,	VII.,	,,	II.,	1879.
,,	II.,	,,	IV.,	1845-6.	,,	VII.,	,,	III.,	1880.
,,	II.,	,,	V.,	1847.	,,	VII.,	,,	IV.,	1881.
,,	II.,	,,	VI.,	1848.	,,	VIII.,	,,	I.,	1882.
,,	III.,	,,	III.,	1851.	,,	VIII.,	,,	II.,	1883.
,,	III.,	,,	V.,	1854-5.	,,	VIII.,	,,	III.,	1884.
,,	III.,	,,	VII.,	1858-9.	,,	IX.,	,,	I.,	1885.
,,	IV.,	,,	II.,	1860.	,,	IX.,	,,	II.,	1887.
,,	IV.,	,,	IV.,	1862.	,,	IX.,	,,	III.,	1888.
,,	IV.,	,,	VI.,	1864-5.	,,	X.,	History,		1837-87.
,,	IV.,	,,	VII.,	1865-6.	,,	XI.,	Part	I.,	1889.
,,	IV.,	,,	VIII.,	1867.	,,	XI.,	,,	II.,	1890.
,,	IV.,	,,	IX.,	1868.	,,	XI.,	,,	III.,	1891.
,,	V.,	,,	I.,	1869.	,,	XII.,	,,	I.,	1892.
,,	V.,	,,	II.,	1870.	,,	XII.,	,,	II.,	1892.
,,	VI.,	,,	I.,	1871-2.	,,	XII.,	,,	III.,	1893.
,,	VI.,	,,	II.,	1875.	,,	XII.,	,,	IV.,	1894.
,,	VI.,	,,	III.,	1876.	,,	XII.,	,,	V.,	1894.

Application for any of the above Parts, to complete sets, to be made to the Hon. Secretary, Hopton, Mirfield. The price of each Part, except Vol. X., to Non-Members is Five Shillings, but a reduction will be made to Members, and also for a series of Parts taken together.

METEOROLOGY OF BRADFORD FOR 1895.

SHEET 1.

Computed from daily observations made at the Exchange, Bradford, by John McLandsborough, M. Inst. C.E. retired., F.R.A.S., F.R.Met.Soc., F.G.S., Alfred Eley Preston, M. Inst. C.E , F.R.Met.Soc., F.G.S., and Henry Arthur Johnson, Assoc. M. Inst. C.E.
Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

MONTHS.	PRESSURE OF ATMOSPHERE IN MONTH.									Corrected for Capillarity and Temperature	
	Highest Reading of Barometer	Date	Highest during 27 Years.	Mean of Highest of 27 Years	Lowest Reading of Barometer	Date	Lowest during 27 Years	Mean of Lowest of 27 Years.	Range.	Mean	Mean of 27 Years.
	Ins	On	Ins	Ins	Ins	On	Ins	Ins	Ins	Ins.	Ins
January	30 260	30th	30 544	30 179	28 606	17th	28 070	28 721	1·654	29 303	29 511
February	30 154	17th	30 412	30 108	29 402	24th	28 340	28 828	0 852	29 704	29·526
March	29 984	16th	30 476	30 128	28 288	28th	28 175	28 774	1 696	29 247	29 491
April	30 041	12th	30 500	30 053	28 97	6th	28 332	28 899	1 074	29 485	29 491
May	30·270	4th	30 382	30 069	29 376	21st	28 661	29 060	0 894	29 704	29 549
June	30 158	24th	30 400	30 04	29 350	19th	28 840	29 177	0 808	29 674	29 570
July	29 950	5th	30 305	29 977	29 050	21st	28 690	29 169	0 910	29 436	29 506
August	29 896	16th	30 232	29 967	28 980	4th	28 670	29 055	0 916	29 446	29 496
September	30 062	21st	30·232	30 076	29 256	11th	28 452	29 026	0 806	29 710	29 534
October	30·236	17th	30 394	30 131	28 720	3rd	28 250	28·728	1 516	29 406	29 445
November	30 190	1st	30 376	30 072	28 664	12th	28·060	28 669	1 526	29 472	29 458
December	30 042	27th	30·358	30 124	28 662	15th	27·652	28 663	1 380	29 341	29 475
Means, or totals	30 104		0 376	30 078	28 935		28·346	28 895	1 169	29 494	29 504

MONTHS.	TEMPERATURE OF AIR IN SHADE DURING MONTH. In Each Month.									Daily Mean. In Each Month				Range		Of Dry Bulb	
	Highest	Date.	Highest during 27 Years.	Mean of Highest of 27 Years	Lowest	Date.	Lowest during 27 Years	Mean of Lowest of 27 Years	Range.	Of all Highest	Mean of 27 Years	Of all Lowest	Mean of 27 Years.	Mean.	Mean of 27 Years	Mean.	Mean of 27 Years
	Deg	On	Deg	Deg	Deg	On	Deg.	Deg.	Deg.	Deg	Deg	Deg	Deg.	Deg	Deg.	Deg	Deg
January	40 4	18th	57·2	52 3	17 2	12th	6 7	22 3	23 2	35 4	42 5	28 8	34 0	7 1	8 5	32 8	38 8
February	44·0	24th	59 8	53 0	9·4	6th	9·4	25·3	34·6	34·6	43 8	25·9	34·9	8·9	8·9	30·5	39·2
March	55 4	23rd	66 0	57 2	27 2	3rd	17 4	25 9	28 2	47 0	46 6	37 4	35 4	9 6	11 2	41 7	40 6
April	60 4	22nd	74·0	63 7	32 4	3rd	25 0	31 3	28 0	53 0	52 7	40 7	39 4	12 3	13 2	46 5	44 8
May	75 0	31st	83 9	70 3	38 0	5th	28 6	35 1	37 0	66 8	58 5	47 0	44 1	14 8	14 4	53 7	49 9
June	73 2	27th	87 8	77 0	42 0	15th	38·0	41 9	31 2	64 1	64 9	53 1	50 3	11 0	14 6	57 7	55 6
July	69 6	9th	89 6	79 0	51·0	12th	42·0	46 9	18 6	64 0	67 7	54 8	55 8	9 2	13 9	58 5	59 8
August	72 6	19th	85 2	77 6	51 2	25th	38 6	45 5	21 4	64 9	66 7	56 6	53 3	8 3	13 4	60 4	58 9
September	72 6	10th	81 3	70 8	43 8	22nd	33 5	40 5	28 8	64 4	61 9	54 0	49 8	10 4	12 2	58 7	54 8
October	62 8	2nd	69 9	62·9	28 8	29th	26 7	32 2	31 0	49 0	53 6	44 4	43 2	7 6	10 4	44 4	48 0
November	60 0	17th	61·5	56 6	36 0	19th	23·0	29 2	24 0	49 1	47 6	42 2	38 7	6 9	8 8	45 6	43 1
December	51·6	6th	57 8	53 1	30 8	28th	13 2	23 4	20 8	43 1	42 9	37 0	34 5	6 1	8 4	40 6	39 2
Means, or totals	61 5		72 8	64 6	34 0		25 2	33 3	27 5	52 6	54 1	43 2	42 6	9 4	11 5	47 6	47 8

MONTHS.	Adopted Mean Temperature. Of Air		Of Evaporation		Dew Point.		VAPOUR. Elastic Force		In a Cubic Foot of Air.				Mean Weight of a Cubic Foot of Air.	Mean of 27 Years	Degree of Humidity. (Complete Saturation — 100)									
	Mean.	Mean of 27 Years.	Mean.	Mean of 27 Years.	Mean	Mean of 27 Years	Mean	Mean of 27 Years	Mean.	Mean of 27 Years	Short of Saturation	Mean of 27 Years			Highest	Date	Highest during 27 Years	Mean of Highest of 27 Years	Lowest	Date	Lowest during 27 Years	Mean of Lowest of 27 Years	Mean.	Mean of 27 Years.
	Deg	Deg	Deg	Deg	Deg	Deg	Ins.	Ins	Grs	Grs	Grs	Grs	Grs	Grs	0–10	On	0–100	0–100	0–100	On	0–100	0–100	0–100	0–100
January	32 6	38 4	31 1	36 7	28 2	34 4	164	20	1 8	2 3	0 4	0 4	552	549	96	14th	100	97	58	28th	34	65	84	86
February	30 3	39·1	29·1	37·4	26·8	35 0	·138	·205	1·6	2·4	0·4	0·4	562	549	84	24th	100	97	46	22nd	42	64	81	86
March	41 5	40 3	39 1	37 9	36 1	34 8	213	203	2 5	2 4	0 6	0 6	54	547	98	1 th	99	96	59	2nd	28	54	82	82
April	45·9	44 7	42 2	41 3	37 9	37 4	230	225	2 6	2 6	0 9	0 8	540	542	98	18th	100	95	47	7th	30	51	74	77
May	53·2	49 7	48 2	45 5	43·2	41 3	279	261	3 1	3 0	1 4	1 1	536	537	84	18th	99	92	40	6th	30	44	69	73
June	57·2	55 8	52 0	51 3	47·2	47 0	325	323	3 7	3 6	1 6	1 4	531	531	9	14th	100	93	44	25th	32	47	64	72
July	58 0	59 5	53 6	54 1	49 6	49 8	357	360	4 0	4 0	1 4	1 6	526	526	93	26th	99	92	46	8th	35	48	74	71
August	59 7	58 6	54 3	54 0	50 6	50 1	370	363	4 1	4 1	1 5	1 5	521	526	88	27th	99	92	47	18th	41	50	72	73
September	58 3	54 8	54 9	51 4	51 8	48 1	386	337	4 3	3 8	1 1	1 0	530	531	93	25th	99	95	63	4th	38	54	79	78
October	44 3	47 7	42 4	45 3	40 1	42 5	249	273	2 8	3 1	0 5	0 7	541	538	97	8th	99	97	58	11th	49	61	85	83
November	45·4	42 8	43 4	40 6	41 1	37 8	258	228	2 9	2 6	0 5	0 5	540	543	97	29th	100	97	66	11th	43	63	85	83
December	40 3	38 9	38 3	36 9	35 7	34 4	210	201	2 4	2 3	0 5	0 5	544	548	94	29th	100	97	51	11th	44	63	84	84
Means, or totals	47·2	47 5	44 1	44·4	40 6	41 0	·264	·265	3 0	3 0	0 9	0 9	539	539	94		100	95	51		37	55	78	79

MONTHS	BRIGHT SUNSHINE.				TEMP. OF AIR IN SUN'S RAYS.			WIND. Direction: Relative Proportion of at 9 a.m.							
	Greatest Daily Duration	Date	Total of Month.	Per cent of Possible Duration.	Highest.	Date.	Mean.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	hr min	On	hr min		Deg	On	Deg.	No	No	No	No.	No	No	No	No
January	4 40	29th	21 0	8	69 0	23rd	66·9	9	2	6	3	0	1	4	6
February	6 30	17th	30 27	11	73 0	26th	68 8	9	9	3	3	0	1	2	1
March	5 10	27th	49 0	11	95 0	18th	75 2	5	1	2	1	4	3	10	5
April	6 30	17th	56 40	14	101 0	22nd	82 3	6	4	4	1	6	6	1	2
May	12 10	6th	109 10	22	110 0	27th	95 9	7	5	5	2	2	0	4	6
June	12 30	8th	97 10	19	108 0	9th	100·3	1	4	3	1	2	3	8	8
July	12 15	8th	113 20	22	109 2	31st	101·3	2	0	5	0	5	3	12	4
August	10 0	25th	110 50	24	109 5	21st	100·8	2	0	0	0	10	7	10	2
September	8 0	16th	115 55	31	109 0	15th	100 1	1	1	1	2	10	4	8	3
October	8 0	7th	68 30	21	99 3	5th	75 7	8	1	2	2	3	2	3	10
November	4 30	13th	22 55	9	82 0	10th	60 6	6	5	1	5	6	5	1	2
December	5 0	14th	17 25	8	75 0	14th	58 9	0	1	8	3	1	8	8	2
Means, or totals	7 56		802 22	18	95·0		80·6	55	33	40	23	49	43	71	51

MONTHS	WIND. Velocity At 9 a.m.			During 24 hours.								Pressure.					
	Mean	Highest.	Date.	Mean.	Mean of 9 years.	Highest.	Date	Highest of 9 years.	Total Registered in Month	Mean of Monthly T't'l of 9yrs	Highest Monthly T't'l of 9 yrs	Mean of all Daily Highest	Mean of all Daily Highst. in 12 Years.	Highest.	Direction.	Date	Mean of Highest of Month of 12 Years.
	Miles p'r hr	Miles p'r hr	On	Miles per d	Miles per d	Miles per d	On	Miles per d.	Miles	Miles	Miles.	lb per sq ft	lb per sq ft	lb per sq ft		On	lb per sq ft
January	5 5	13 0	27th	104	154	225	24th	473	3227	4778	6724	0·60	2 62	5 0	NNW	24th	10 06
February	4 0	8·9	1st	92	161	169	27th	591	2579	4557	6443	0 39	2 53	3 7	W	27th	9 93
March	6 2	16 6	19th	136	155	396	24th	559	4220	4822	5803	1·33	2 20	6 5	S W	25th	8 96
April	6 2	15 6	10th	130	137	250	11th	359	3900	4103	5563	0 97	1 86	6 3	W S W	7th	6 4
May	6 3	15 0	17th	123	141	280	17th	376	3798	4370	5344	0 63	1 95	5 2	N	17th	6 72
June	4 7	9 4	7th	112	127	162	11th	282	3357	3807	4764	0 18	1 42	1 0	N E	8th	5 11
July	6 0	13 3	15th	125	135	262	15th	359	3869	4181	4771	1 01	1 61	6 3	W	15th	5 73
August	6 6	13 0	28th	138	133	238	31st	493	4264	4111	4603	0 73	1 64	4 4	W	31st	6 60
September	6 2	14 8	22nd	101	129	272	12th	381	3023	3881	4873	0 70	1 77	8 8	S W	12th	6 7
October	5·9	16 6	7th	121	140	327	12th	390	3748	4434	5127	1 29	2·07	6 6	W S W	12th	8 80
November	6·2	16·8	16th	164	152	379	17th	490	4915	4571	7853	1 31	2 20	8 2	S	16th	9 27
December	7 0	24 3	5th	166	143	684	5th	584	5141	4432	6440	2 34	2 58	15 2	S W	5th	10 75
Means, or totals	5 8	14 9		126	142	295		445	46052	5 947	5610	0 96	2·03	6·4			7·92

MONTHS	Mean Amount of Cloud	RAIN.							Gr'ter fall on surface at Town Hall & Mid Stn than at 65½ft above surface at Exch	
		Number of Days it fell	Greatest Daily Fall	Date	Amount Collected	Mean of 26 Years	Mean of Eight Years ending with 1882, 65½ft above surface of ground	Mean of 8 Yrs endg with 1882 at T'n Hall and Mid Ry Station on surface of ground	Depth in Inches.	Percentage of fall at Exch'ge
	0–10	No	Ins	On	Ins	Ins	Ins	Ins	Ins	Per cent
January	7 8	24	0 59	21st	3 45	2 59	2 209	2 474	0 265	11 2
February	6 7	5	0 16	1st	0 24	1 33	2 609	2 972	0 363	11 4
March	7 6	19	0 50	10th	2 51	2 10	2 776	3 260	0 484	11 7
April	6 5	14	0 68	26th	2 72	2 01	2 516	2 835	0 319	11 2
May	4 7	6	0 12	2nd	0 25	1 84	2 103	2 277	0 174	10 8
June	6 4	10	1 60	27th	2 65	2 27	2 837	3 011	0 174	10 6
July	6 7	23	22	5th	6 37	2 97	3 401	3 641	0 240	10 7
August	6 6	14	0 59	12th	2 33	2 67	3 654	3 892	0 238	10 7
September	5 3	7	0 61	7th	1 20	2 42	2 894	3 229	0 335	11 2
October	7 2	16	0 65	4th	2 61	3 52	3 640	4 012	0 372	11 0
November	8 0	21	0 47	6th	3 33	2 77	3 421	3 828	0 407	11 2
December	8 8	17	0 45	13th	2 83	2 63	3 681	4 170	0 489	11 3
Means, or totals	6 9	181	0 63		30 49	29 67	35 741	39 601	3 860	11 08

METEOROLOGY OF BRADFORD FOR 1895.

YEARLY MAXIMUM AND MINIMUM ATMOSPHERIC PRESSURE, TEMPERATURE, HUMIDITY, BRIGHT SUNSHINE, WIND PRESSURE, AND RAINFALL.

Year.	Pressure. Highest. Reading of Barom during Year.	Pressure. Highest. Date.	Pressure. Lowest. Reading of Barom during Year	Pressure. Lowest. Date.	Temperature. In Shade. Highest. R'ding of Maximum Thermom during Yr	Temperature. In Shade. Highest. Date	Temperature. In Shade. Lowest. R'ding of Minimum Thermom during Yr	Temperature. In Shade. Lowest. Date	Temperature. Last and First Frost of Seasons. Date of Last Frost.	Temperature. Last and First Frost of Seasons. Date of First Frost.	Temperature. In Sun's Rays. Highest. Reading of Solar Thermom during Yr	Temperature. In Sun's Rays. Highest. Date.	Humidity. (Complete Saturation = 100.) Highest. Degree of Humidity during Yr	Humidity. Highest. Date.	Humidity. Lowest. Degree of Humidity during Yr	Humidity. Lowest. Date.	Bright Sunshine. Greatest Daily Duration	Bright Sunshine. Date.	Bright Sunshine. Total of Year.	Bright Sunshine. Per cent of Possible Duration	Wind Pressure. Highest.	Wind Pressure. Date	Rain. Total for Year	Rain. Mean Y'ly Rainfall at Town Hall and Mid Rly Stn on surface of gr'nd	Rain. Gr'tr fall on srfce at Tn H'll & Mid Stn than at 65 ft ab've surf at Exc. Depth in Inches	Rain. Gr'tr fall on srfce at Tn H'll & Mid Stn than at 65 ft ab've surf at Exc. Percentage of fall at Exch'ge	Rain. Greatest Daily Fall during Yr	Rain. Date	Snow. Last and First Snow of Seasons. Date of Last Snow	Snow. Last and First Snow of Seasons. Date of First Snow.
	Ins.		Ins.		Deg.		Deg.				Deg.		0—100		0—100		hr. min		hr. min.		lb. per sq ft		Ins.	Ins.	Ins.	Per cent	Ins.			
1869	30 290	Dec 6	28·500	Feb 1	85·2	Aug 30	19·8	Dec 28	Mar. 27	Oct. 20	127·7	Aug. 30	99	Feb. 8	42	Sep 24												.....	April 3	Oct. 19
1870	30 284	Jan 19	28 308	Jan 8	85 0	July 25	16 6	Dec 23	Mar 30	Nov. 9	127 5	July 25	98	Jan. 29	28	Mar. 8							24 120				0 820	June 18	Mar 24	Nov 15
1871	30·162	Mar. 28	28·308	Jan. 16	84·0	Aug. 12	6·7	Jan. 1	April 11	Nov. 13	128·7	July 17	98	July 7	43	Nov. 2	......	......	......	......	......	......	21·640	......	......	......	0·985	June 16	Mar. 15	Nov. 16
1872	30 156	April 6	28 070	Jan 24	86 4	July 23	24 8	Mar 27	Mar 27	Nov 19	124 8	Aug 19	100	Mar 22	45	Sep 23							42 060				2 490	June 19	May 11	Nov 13
1873	30·338	Feb. 18	28·022	Jan. 20	88·8	July 23	19·2	Feb. 24	Mar. 14	Nov. 5	124·5	July 23	100	Dec. 11	41	Mar. 26	......	......	......	......	......	......	21·440	......	......	......	1·200	Aug. 4	April 25	Jan. 3, '74
1874	30·476	Mar. 6	28·276	Dec. 11	80·9	July 20	15·0	Dec. 31	Mar. 12	Nov. 11	125·8	July 20	100	Feb. 6	42	May 18	......	......	......	......	......	......	23·560	......	......	......	0·740	Dec. 7	May 9	Nov. 26
1875	30 305	July 7	28 484	Nov. 10	80 0	Aug 17	13 0	Jan. 1	Mar 22	Nov. 26	122 0	July 5	100	Jan 23	43	July 6							30 280				1 700	Nov. 15	Mar 12	Nov 9
1876	30 300	Jan 15	28 070	Dec 4	87 6	July 17	23 0	Jan. 9	April 15	Nov. 9	125 6	July 16	99	Oct 4	46	May 6							35 270	39 788	4 518	11 28	1 810	Oct 9	April 12	Nov. 8
1877	30 358	Oct. 6	28 300	Nov 29	80 0	June 19	20 0	Mar 1	May 4	Oct. 18	116 4	June 19	100	Oct. 29	35	May 23							40 650	45 499	4 849	11 19	1 420	July 16	May 19	Oct 15
1878	30 320	Mar. 16	28 630	April 1	89 6	July 19	13 9	Dec. 26	April 6	Nov. 9	118 2	July 22	99	Jan. 13	53	Aug 9							35 434	39 010	3 576	11 01	1 220	Aug 14	April 1	Nov 8
1879	30 352	Dec. 13	28 500	Feb 10	74 4	July 30	13 2	Dec 7	May 10	Nov 14	101 2	Aug 13	100	Oct 7	51	Dec 12							28 017	30 298	2 281	10 82	1 020	June 8	May 7	Nov 20
1880	30 332	Jan 7	28 154	Nov 16	81 3	Sep 5	20 8	Jan. 20	Feb 23	Oct. 20	112 0	Aug 13	99	Dec 15	50	May 30							35 690	39 616	3 926	11 10	1 710	Oct 27	Mar 2	Oct 27
1881	30 382	May 10	28 250	Oct 14	63 3	July 6	12·0	Jan 26	April 21	Oct. 17	116 5	June 1	98	Oct 14	38	May 31							35 434	39 892	4 458	11 26	1 435	Oct 13	April 20	Oct 29
1882	30 544	Jan 18	28 452	Mar 1	77 4	Aug 12	18 6	Dec 11	April 16	Nov 12	108 0	Aug. 9	99	Nov 5	36	May 18							39 683	43 103	3 420	10 86	1 608	Dec 6	Mar 21	Nov 19
1883	30 500	April 9	28 452	Sep. 2	76·2	July 3	19·8	Mar. 10	Mar. 29	Nov. 12	107·6	May 17	99	Dec. 26	30	April 9	......	......	......	......	......	......	34·396	......	......	......	1·338	Sep. 26	Mar. 24	Nov. 10
1884	30 354	Oct 5	28 376	Jan 27	84 4	Aug 12	26 5	Nov. 30	April 24	Nov 24	107 8	Aug 9	98	Jan 23	30	May 22					24 00	Jan. 24	27 657				1 170	Jan 23	Feb 28	Nov 23
1885	30 273	Mar 14	28 400	Jan. 11	82·2	July 27	22·1	Dec. 11	April 6	Nov. 16	113·6	July 27	100	Jan. 23	32	June 4	......	......	......	......	15 25	Dec. 4	25 699	......	......	......	1·208	Sep. 3	May 7	Dec. 9
1886	30 355	Nov. 24	27 652	Dec. 8	79 5	July 3	17 4	Mar 7	April 30	Dec 2	108 8	July 5	99	Jan 12	32	May 4	11 45	July 6	851 48	19	18 00	Dec 9	35 993				2 130	July 26	May 12	Nov. 6
1887	30 412	Feb. 8	28 328	Nov 3	82 8	July 9	21 1	Jan. 17	April 17	Oct 12	107 6	July 9	100	April 21	35	July 9	12 40	July 3	1120 58	25	15 00	Feb 4	18 665				0 810	Oct 9	May 21	Oct. 14
1888	30 333	Jan. 10	28 410	Mar 28	80 4	June 27	19 2	Feb. 14	April 8	Oct. 2	110 0	Sep 15	99	Mar 15	39	June 11	13 40	May 24	984 20	23	13 00	May 4	25 616				1 050	Nov. 3	April 8	Oct 1
1889	30 358	Dec. 5	28 450	Mar. 2	77 5	Aug 1	21·3	Mar 4	Mar. 22	Nov 27	115 2	June 23	99	April 22	39	June 26	12 15	July 8	827 45	18	12 00	Feb 9	22 141				0 590	Mar 9	Mar. 21	Nov 25
1890	30 375	Feb. 23	28 315	Jan. 23	76 4	Sept. 10	18 4	Dec. 22	Mar. 10	Oct 28	111 0	June 16	91	May 11	31	May 29	14 25	May 25	824 6	18⅓	14 0	Jan 19	25 730		....		1 445	Jan. 22	April 13	Oct. 21
1891	30 394	Oct. 31	28 010	Nov 11	79 9	Sept 12	12 0	Jan 19	May 18	Nov. 25	107 0	July 27	100	Feb 20	37	July 17	11 45	May 12	805 35	18	13 60	Aug 26	27 303				1 020	Dec. 1	May 17	Nov 26
1892	30 256	Mar. 30	28 638	Feb 2	77 0	Aug 24	18 8	Feb. 13	April 19	Oct. 25	107 5	July 23	99	Jan 12	32	April 3	12 30	June 7	866 53	19	10 00	April 28	28 681				2 720	Oct 15	April 28	Oct. 24
1893	30·358	Dec 30	28 300	Feb 26	75 0	Aug. 19	19·0	Jan 6	April 12	Oct 31	117 8	Aug. 19	98	Mar 1	37	April 25	13 0	May 10	980 36	22	13 20	Nov. 19	22 667			......	1 180	May 18	Mar 17	Nov. 5
1894	30 302	Dec. 27	28 512	Oct. 25	80 8	July 1	10 2	Jan 6	Mar. 17	Oct 22	105·2	July 9	100	Jan 8	40	July 5	12 45	July 1	771 28	17	13 00	Dec. 23	32 782				1 114	Oct 27	Mar 13	Dec 29
1895	30 27	May 4	28 288	Mar 28	75 0	May 31	9·4	Feb. 8	Mar 12	Oct 28	110 0	May 27	98	April 18	41	May 6	12 30	June 8	812 22	18	15 20	Dec. 5	30 491				1 60	June 27	April 7	Oct. 26
Means	30 338		28·385		81 5		17 5				115 1		89		39		12 44		873 35	20	15 10		29·666	39 601	3 860	11 08	1 367			

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p.m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level (the air temperature being 48 degrees and barometer 30 inches at sea level), add ·401 inch to the heights given.

A remarkable instance of barometric depression occurred on the 8th December, 1886, when at 8.40 p.m. the mercury of the Exchange barometer had fallen to 27·456 inches only—the lowest reading on record here. The cyclone indicated by this depression was the cause of great loss of life and property, extending over an unusually large district.

All thermometric observations and deductions are given in degrees Fahrenheit.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

Bright sunshine is recorded in hours and minutes by glass sphere on cards, known as Campbell's recorder, fixed on Professor Stokes' zodiacal frame.

The solar thermometer has a black bulb enclosed in a vacuum.

The direction, velocity, and pressure of wind are recorded as indicated by anemometers fixed 10½ feet above the ridge of roof of Exchange. The velocity per hour at 9 a.m. is determined from anemometer readings made one minute and a half before and a like period after that hour, by multiplying the difference thereof by 20. The pressure is given in pounds avoirdupois per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10.

Rainfall includes melted snow and hail.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and 395 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1875 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3·86 inches, or 11·08 per cent., greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the twenty-six years ending with 1895 is 29·666 inches. By adding 11·08 per cent. thereto the mean normal rainfall of central Bradford for such period is found to be 32·953 inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange—and on buildings generally—than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed. The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of central roof—the place it has since occupied. To avoid risk of inaccurate results, the rainfall of 1869 is omitted from these returns.

The instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory, excepting those which can be verified by measurement.

PROCEEDINGS
OF THE
YORKSHIRE
GEOLOGICAL AND POLYTECHNIC SOCIETY.

NEW SERIES, VOL. XIII., PART II., pp. 135—278.

With Ten Plates,
and Twelve Photographs of the Chalk of Flamborough Head.

Edited by W. LOWER CARTER, M.A., F.G.S.,
and WILLIAM CASH, F.G.S.

1897.

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Edited by W. LOWER CARTER, M.A., F.G.S.,
and WILLIAM CASH, F.G.S.

1896.

A HISTORY OF THE DROPPING WELL AT KNARESBOROUGH WITH THE ANALYSIS OF THE WATER. BY B. A. BURRELL, F.I.C.*

(*Read 1st August, 1896.*)

History.

From the proximity of Knaresborough to the ancient Brigantian capital of Aldborough it is probable that it was a centre of population long before the coming of the Romans, whom there are good reasons for believing established a station in this district. It is therefore likely that the Dropping Well has been known from very remote times, as its remarkable petrifying qualities could not easily escape the notice of dwellers in the vicinity.

The first reference that I have been able to find is that in the year 1488, the celebrated Mother Shipton was born at Knaresborough, near the Dropping Well.

Its character was well known in 1534, for Leland thus describes it (Leland's Itinerary) :—

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* The analysis of the water was communicated to the Chemical Society of London during the early part of the present year, and has appeared in their Transactions. The historical portion of this paper has been written specially for the Yorkshire Geological and Polytechnic Society.

19623

"A little above March Bridge, but on the farther ripe of Nidde as I cam, is a Welle of a wonderful nature, caullid Dropping Welle, for out of the great Rokkes by it, distilleth water continually ynto it. This water is so could, and of such a nature, that what thing soever faullith oute of the Rokkes ynto this pitte, or ys caste in or growith aboute the Rokkes and is touchid of this water, growith ynto stone; or else sum sand, or other fine ground that is aboute the Rokkes, cummith doune with the continualle droping of the Springs in the Rokkes, and clevith on such things as it taketh, and so clevith aboute it and giveth it by continuance the shape of a stone. There was ons, as I hard say, a conduct of stone made to convey water from this welle over Nidde to the priory of Knaresborough; but this was decayed afore the dissolution of the house." It would, therefore, appear that some time prior to 1534, the water was used for drinking purposes.

Camden in 1607 states, "A spring fed not by water rising out of the ground, but by drops falling from the rock above, whence it is called the Dropping Well, in which whatever wood is thrown is soon incrusted with a coat of stone and petrified."

In the first medical treatise on the Harrogate waters, written by Dr. Dean in 1626, we find "Besides great plenty of Springs of common water, we have here Five worthy the Physicians Observation; the first whereof, over against the Castle, is called the Dropping Well, because it drops, distils and trickles down from the Rock above, the water whereof is of a petrefying nature, turns everything to a stony Substance in a short time. . . . . It's said to be effectual in staying any Flux of the Body."

Four years later, in 1632, Dr. Stanhope writes, "There is also a dropping petrifying well, which cures Fluxes of the Belly; instances whereof we have seen."

The first examination of the water was by Dr. French in 1654. "He evaporated the water, and in the bottom remained a stony powder, like the powder of the stones of the rock. A pint of it weighs ten grains heavier than a pint of common water. . . . . . It's chief virtues are, to allay acid, gnawing and hot choleric humours, and to stop all fluxes proceeding from thence. . . . . The quantity of water to be drunk in a day, is, from half a pint, to half a gallon, according to age, constitution, disease and place affected." It is included amongst "the five famous medicinal wells of the Yorkshire Spaws, near Knaresborough," by Dr. Neale, in 1656.

From 1660—1678 a very bitter controversy was carried on between Drs. Witty, Simpson, and Tonstal regarding the composition and medicinal virtues of the Dropping Well, the Knaresborough Sweet Spa (now known as the Harrogate Old Spa or John's Well), and the Scarborough Spa. The waters were examined by the several disputants, and many references are made to the Dropping Well; thus we are told "It often cures inveterate Fluxes . . . and a Diabetes," and "the Dropping Well and it (Scarborough Water) only differ in this, that one incrustates sticks and the other people's bowels." This controversy became of such a personal character that it was taken notice of, and reproved publicly by the then Secretary of the Royal Society.

In 1679 Ralph Thoresby, the celebrated antiquarian, visited Knaresborough, and saw "the admirable petrifying well."

Dr. Short, of Sheffield, published his treatise on mineral waters in 1734. This work was so highly esteemed at the time that it was printed at the request of the Royal Society. He states "The most noted of the petrifying waters in Yorkshire is the Dropping Well at Knaresborough, which rises up about fourteen yards below the top of a small mountain of marlstone (properly a limestone of a very coarse grain) on the west side of the town and river, and about twenty-six yards from the bank of the Nid; then it falls down in the same contracted rapid stream about a yard, and at a second fall at two yards distance it comes two foot lower, then three or four, and so falls upon an easy ascent, divides and spreads itself upon the top of an isthmus of a petrified rock generated out of the water there falls down round it; about four or five yards from the river the top of this isthmus or rock hangs over its bottom four yards. This rock is ten yards high, sixteen yards long, and from thirteen to sixteen yards broad. This little island slipt down and started from the common bank about thirty years ago, and leaves a chasm between them from a yard and a-half to three yards wide. This spring sends out about twenty gallons in a minute of the sweetest water I ever tasted. . . . . . . It springs out of a small hole like a little sough in the middle of a thick set of shrubs. This little isthmus is beatifully cloathed with ash, osier, elm, ivy, sambocus, ceincaria major, geraniums, wood mercury, hartstongue, sage, ladies' mantle, scabious, cowslips, wild angelica, meadow sweet, &c. This water both at the spring and from the rocks is of equal weight, and each twenty-four grains in a pint heavier than common water. I exhaled eighteen pints of this water from the spring, and it left seventeen scruples of sediment."

It is classified by Dr. Elliott in 1781 as "a water containing an earth." He further states "the dose has formerly been several quarts in the day, but three or four half-pints are now judged sufficient."

In 1783 Dr. Walker, Physician to the General Infirmary at Leeds, made some qualitative tests of the water, and sums up the result of his examination by stating that "the petrifying spring at Knaresborough contains a considerable quantity of *selenitical* and a smaller quantity of *calcareous* earth." As will be shown by the analysis which follows, the predominant constituent of the water is calcium sulphate, *i.e.*, the selenitical earth. Dr. Walker may therefore claim the credit of being the first to discover the real nature of the water.

Dr. Adam Hunter's treatise on the Harrogate Waters was published in the year 1830. In it we find what may be considered the first real analysis of the water. In the local guide books this analysis is usually referred to as being by Hunter. This is incorrect, as it was made by Mr. W. West, of Leeds, and this is so stated by Dr. Hunter in his preface. Mr. West appears to have made a special study of the mineral waters of Yorkshire, more especially of the West Riding, for in the British Association Reports, 1844, there is a paper by W. West giving the analyses of some fifty of the Yorkshire mineral waters.

His numbers were :—

Saline contents in grains per Imperial Gallon :—

Carbonate of Lime ...	23
Sulphate of Lime ...	132
Sulphate of Magnesia ...	11
Carbonate of Soda ...	6
Iron	trace
Solid contents on evaporation	172

Gases yielded by the water in cubic inches per Imperial Gallon :—

Carbonic Acid	7
Azote	8
Oxygen	1
Total ...	16

Specific Gravity of Water - 1·0032

Dr. Hunter considered that under proper management it would be a valuable remedy in some cases of Scrofula, Atroply and Rickets. This appears to be the last reference to its medicinal qualities, and the fame of the water now rests solely upon its petrifactive action.

It may be of interest to state that at the present time waters of a somewhat similiar composition, but very *much less concentrated* than that of the Dropping Well, are not considered suitable for drinking, and to those of a gouty tendency they would be decidedly injurious.

So far as I am aware, no analysis has been published since 1830, and it seemed very desirable that a more complete examination should be made of this curious water. The writer commenced the analysis in 1881, but for various reasons it was never completed. The work was again taken up in 1894 and extended over the following year, various samples of the water having been taken from time to time.

Knaresborough is situated on the Permian formation, mostly Magnesian Limestone. The Dropping Well is in the Long Walk, planted by Sir Henry Slingsby in the year 1730, and situated on the south-west bank of the river Nidd, where the water rises in the steep declivity of a hill, and flows in a small stream for about 24 yards. It is then caused to spread over the surface of a large rock, some 30 feet high and 45 feet long, over which it trickles. The upper part of this rock projects considerably over the base (as in Dr. Short's time), and it is to this projection that the articles to be petrified are hung. The projecting portion of the rock is scraped at intervals of six or seven weeks in order to prevent it becoming top heavy.

The water for analysis was collected immediately as it issued from the ground ; at this point it is very clear and free from suspended particles. The flow is about 20 gallons a minute, and the temperature very constant, two readings giving :—

August ... Temp. of air, 15·5° C. ; temp. of water, 9·7° C.
December ,, ,, 2·0° C. ; ,, ,, 9·0° C.

Analysis. The general course adopted was that recommended by Fresenius ; the numbers given are the means of at least two, and in some cases three or more concordant results. For the estimation of substances present in minute quantity, 25 litres (5½ gallons) were evaporated, but no traces of bromine, iodine, fluorine, or lithium could be detected. The negative results in searching for these elements is confirmed by the small quantities of chlorine and alkalies present in the water.

*Strontium Sulphate was found on the banks of the Nidd, at Knaresborough, so far back as 1811, but has not previously been detected in this water, in which it is now shown to exist to the extent of over ½ a grain per gallon. This comparatively rare element is also present in the Knaresborough Bilton Spa Water, but in this case it exists as carbonate.

In the first table the quantities of the different constituents are given in grams per litre under I., and in grains per gallon under II.

Constituents per Litre and per Gallon.

	I. In grams per Litre.	II. In grains per Gallon.
Carbon Di-oxide	0·1614	11·298
Silica	0·0107	0·749
Sulphuric Acid	1·3524	94·668
Chlorine	0·0270	1·890
Iron	0·0011	0·077
Manganese	0·0006	0·042
Calcium	0·6330	44·310
Strontium	0·0046	0·322
Magnesium	0·0491	3·437
Sodium	0·0156	1·092
Potassium	0·0035	0·245

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* See Trans. Geol. Soc. 1817, 4, 445 ; also Edin. Phil. Journ., Jan. 1825, 12, 178, 179.

Ammonia	0·00002	0·0014
Aluminium	trace	trace
Phosphoric Acid	trace	trace
Nitrous Acid	none	none
Nitric Acid	none	none

It is impossible to state precisely how the various acids and bases are combined together, but there are good reasons for believing that the following table represents the composition of the dissolved mineral constituents present in the water.

III. Dissolved Saline Constituents in grains per gallon :—

Calcium Sulphate	114·373
Calcium Carbonate	25·480
Calcium Silicate	1·442
Strontium Sulphate	0·672
Magnesium Sulphate	17·003
Ferrous Carbonate	0·154
Manganous Carbonate	0·084
Sodium Chloride	2·765
Potassium Chloride	0·462
Alumina	trace
Phosphoric Acid	trace
	162·435

Fixed residue by evaporation dried at 170° - 180° C. 162·324

Specific Gravity at 15·5° C. ... ... 1·0024

IV. Gases dissolved by the water in cubic inches per gallon, and measured at 15·5° C., and 760 m.m.

Carbon Di-oxide	4·74
Oxygen	1·29
*Nitrogen	5·02
Total	11·05

It may be noted that the water is very free from organic matter, as is often the case with hard waters. The solubility of Calcium Sulphate, in water at the ordinary temperature, is about 1 part in

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*Not examined for Argon.

430 of water, or 162 grains per gallon (parts per 70,000). This water is, therefore, not far short of being a saturated solution of Calcium Sulphate or Gypsum. The amount of dissolved Carbon Dioxide in the water, by means of which the Calcium Carbonate is kept in solution, is small, and it is probable that this, in conjunction with the very large quantity of dissolved Calcium Sulphate, are the main reasons for the petrifactive action of the water. This, however, cannot be properly decided without a careful analysis of the sinter, which the writer hopes to carry out at some future period.

It has been shown that the water is but slightly affected by atmospheric variations of temperature, it is therefore reasonable to suppose that it rises from a considerable depth, and from its composition it must have percolated through strata containing a considerable amount of gypsum. In various places in Yorkshire I believe deposits of this substance have been found in the Permian strata, but I am unable to say whether they have been noticed at Knaresborough.

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ERRATA.

Page 138, line 7, for Ceincaria read Cervicaria.
,, 138, ,, 7, for Sambocus ,, Sambucus.
,, 139, ,, 10, for Atroply ,, Atrophy.

KILLING PITS. BY J. R. MORTIMER.

(Read 8th May, 1896.)

Killing Pits are some mysterious excavations on the north-west brow of the Goathland Moor, between Scarborough and Whitby, about 1½ miles south-west of Goathland Church. Of these and others much has been written at various times, and by many authors; and various have been the views given to account for them.

By early writers on antiquities these and others similar have been described as Pit Dwellings and the sites of British villages.

Professor Phillips thus writes :—"In several places these pits are associated in such considerable numbers as to give the idea of a village. Such are the Killing Pits, on the gritstone hill, less than one mile south of Goathland Chapel; the pits in Harwood Dale: those which encircle Rosebery Topping; besides many on the side of Glaizdale, and in other situations."

The following abstract is from a rather lengthy paper on Pit Dwellings by the Rev. J. C. Atkinson, Vicar of Danby (now Canon of York), in the *Gentlemen's Magazine* for 1861 :—After having described several clusters of pits, he adds "The Goathland settlement occupies a space of 600 feet by 150 feet, but the pits are not so thickly clustered as in that last-named. The name by which this site has been known, time out of mind, is Killing Pits." He also remarks, "Besides these, several others might be named."

The above extract clearly proves that Canon Atkinson, like most other Archæologists, firmly believed in the habitation theory. Afterwards, however, he changed his views, and in a letter to the *Whitby Times*, April 6th, 1889, strongly combats the habitation theory, and in referring to the Killing Pits says that, "In nearly every case, if not in every case, the so-called British Villages were neither more nor less than the traces left by mediæval iron mining." He also gives from old documents three other instances of Killing Pits in the neighbourhood of Danby, viz.: Hither Killin Pits, Far Killin Pits, and the Lower Killin Pits.

Again, in another letter to the same paper, May 3rd, 1889, Canon Atkinson further supports his belief that the Killing Pits on Goathland Moor were the shafts, or pits, sunk for the purpose of extracting ironstone.

Lastly, in his "Forty Years in a Moorland Parish," published in 1891, page 170, he still supports this view, and at page 174 he adds, "for my own part, if only the opportunity could be achieved, I should go in for an examination of any of these so-called British Villages with very definitely preconceived opinions as to what should be looked for and the way in which the looking for it should be conducted. And for one thing, I should have no more doubt about finding horizontal operations than about the fact that the pits were there. If I did not find the ironstone, it would be because it had been removed."

This seems strong faith, akin to that of an antiquary of a past age, without the least attempt to prove it by the simple application of the pick and shovel.

From the several occurences of the name of Killing Pits given by Canon Atkinson from old documents, it seems almost certain that their name was derived from Kiln and Pits. In other words, pits from which material had been obtained for the kiln, such as ironstone for smelting, or it might be, in some cases, limestone for burning into lime. This name would be most natural and expressive, and could hardly have had any other meaning. But then the name might often have been given to similiarly-shaped old pits which had not been formed by quarrying for the kiln, and possibly the pits under discussion are an instance of this.

On June 10th, 1892, in company with the Rev. E. M. Cole, of Wetwang, I visited the Killing Pits. From descriptions of them, and impressed with antiquarian tendencies, we expected they would be found uniformly circular and regular in size, just such as we had been led to think the remains of sunk dwellings of a circular form might be. In this, however, we were undeceived. These pits are very irregular, both in shape and size, and also in arrangement, and we unanimously agreed that few, if any of them, were the remains of habitations. They measured from 3 feet to 20 feet in diameter, and from 1 foot to 5 feet in depth, and we thought it probable that none of them had originally been more than 10 to 12 feet in depth. Pits most certainly they are, and probably many of the shallow ones were made at various periods in obtaining, for different purposes, the slabs of gritstone which were near the surface, and which would be more easily procured at this outcrop of the beds than in most other places on the moors. Most of the slabs of gritstone which are found in the neighbourhood of Killing Pits vary from 6 to 12 inches, or little more, in thickness, and have been no doubt obtainable in all sizes up to 12 and 15 feet square. Were not at least some of these pits excavated for the purpose of removing such slabs, to be cut into the tall boundary stones, several of which we have observed standing on the moors, and which were probably at one time more numerous than now? They are of the same texture as the gritstone slabs remaining *in situ* at Killing Pits. Again, several of the pits may have been made by the Ancient Britons in quarrying to obtain the side and cover stones to form the burial chambers (Kistvæns) for the reception and protection of their dead placed in the tumuli of that neighbourhood. For such a purpose the most suitable stones, most readily obtained, would be procured from these outcropping beds at Killing Pits, where little more than the removal of the turf would be needed to reach slabs of a suitable size and thickness. It may be noticed that the beds are cracked in every direction, often more or less displaced, broken, and tilted on edge, sufficiently to form separate slabs, so that their extraction would not be difficult. That such slabs were long since used by the Ancient Britons living on the moors round the Killing Pits we have ample evidence from the stone cists found in the tumuli, and also from finding several of the boundary posts marked with small cup and other engravings upon them, of the Ancient British period. These boundary-stones, on which are shown cup markings and other ancient mystic sculpturing, are most certainly portions of broken-up slabs which have come from ancient burial chambers. The irregular size and form of many of the Killing Pits are just such as would be left by the obtaining of boundary posts or slabs suitable for the construction of stone chambers for interring the dead Slabs of various sizes would be required, and where a large one was raised a large pit would be left, and where a small one was taken the excavation would be small, much in the same way as we now find many of the Killing Pits differing in size.

May 12th, 1893, I again visited these pits, and this time in company with Mr. Chadwick, of Malton, and under very favourable conditions, the weather being exceedingly fine and dry, and the ground in a great measure freed of the heather by recent fires on the moors. Under these circumstances the pits were shown to be more varied in size, more numerous, and to cover a greater area than I was led to believe on my first visit. Most of them occupy irregular postions, and are only partially in two rows. Mr. Chadwick called my attention to a large flat stone (which I had previously seen) in the centre of a hole in the ground, about half a mile south of the Killing Pits. This large flat stone had been bared and excavated all round, but from some cause or other had not been removed. On my arrival at the place Mr. Chadwick remarked that if this stone had been removed it would have left an excavation similar to many of those at Killing Pits. My reply was that I had come to the same conclusion on my first visit, and showed him the notes I had then made. A few days after Mr. Chadwick sent me the following note of information he had gathered from residents in the neighbourhood :—" The people living in Goathland, or the freeholders, have a right, from time immemorial, of collecting or quarrying stone on the moors. The Killing Pits are merely the remains of—or traces left of—such excavations, and probably not ancient British at all. Stones are to be found in all sorts of positions, in different parts of the moor. Some are edge way up ; others are flat ; but in many cases some depth would have to be dug to lift them from their positions. This process would leave similar cavities to those shown by the Killing Pits." Thus Mr. Chadwick and myself were at one respecting the probable origin of many of these pits. Besides these Killing Pits, similar dish-shaped hollows, produced by the stubbing up of large trees, are often visible on many of the untilled sites of old forests—such as Beverley Westwood and other places, also in numerous places on the Wold hills of Yorkshire, where chalk and flints have been quarried in early times, and are often erroneously believed to be the foundations of Pit Dwellings.

Since writing the preceding, I have seen the memoirs of the Geological Survey of the United Kingdom, and at page 236, Mr. C. Fox-Strangways, F.G.S., thus writes of Killing Pits: "A good deal of mystery hangs over these pits, and various theories have been started to account for their origin, but there can be little doubt that they are ancient workings for this impure ironstone. Similar shallow pits occur at many other places on these moors, but always just over the ironstone."*

After these conflicting opinions and the firm assertions of so able a geologist as just quoted, a re-examination of these pits with the assistance of the pick and the spade seemed desirable. Therefore, on the 26th and 27th of July, 1893, with the assistance of two workmen, I excavated four of the most circular in form, but variable in size. The first was a medium-sized pit, one of the larger class. After having removed the peaty turf and rubbly soil beneath, which had accumulated to a depth of 18 inches, apparently during a lengthy period, the filling-in of the pit was found to be a mixed-up material, consisting of clay, peat, disintegrated gritstone, and a few gritstone blocks of various sizes, such apparently as had been cast from an adjoining pit in sinking it. These rested on a central depressed bed of almost pure peat-earth, varying from 5 to 10 inches in thickness. This had either accumulated during a considerable period at the then bottom of the pit previous to the casting in of the superincumbent matter, or had been the turf removed from the surface and cast there in excavating an adjoining pit. However, this was not the original bottom of the pit, as we observed under it a very similar mixture to that met with above. This mixture was observed to extend 5 feet below the layer of peat, and as we proceeded downwards it readily peeled from off the firm sides of the original pit, which had been quite circular, with vertical sides, and had reached 11 feet in depth, with a diameter of 8½ feet from top to bottom. The depth penetrated was through beds of disintegrated gritstone (moor grit), divided by beds of more or less clayey and shaley matter (calcareous shale).

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* Memoirs of the Geological Survey of the United Kingdom. The Jurassic Rocks of Britain, vol. 1.

There was no trace of a band of impure ironstone observable in the sides, or at the bottom of the pit, neither was there tunnelling, or even undermining at the bottom, giving the pit the bell-mouth shape so firmly expressed by Canon Atkinson.

After excavating (clearing out) the other three pits, we found they had originally measured from 5½ to 6½ feet in diameter, and from 4 to 4½ feet in depth. The sides of these were not quite vertical, and the bottoms were more or less roughly dished, just as they would have been made in extracting stone slabs. The outlines of all the pits were very clearly shown by their sides having been stained a dark colour, from the percolation of water charged with peaty matter finding its way down the sides of the original pit, between the filling-in. We could find no evidence of their ever having been pit dwellings, neither could we find any trace of ironstone having been extracted from the pits we examined. Still, some of the larger and deeper ones may have been made in searching for ironstone, and a little may have been extracted, as small quantities of this impure stone were observed in the sides of the little gullies, at a little lower level on the escarpment near the pits. Besides, some of the larger may have been made in obtaining calcareous shale to be used as a flux, or to otherwise aid in reducing the ores believed to have been smelted in the bottom of the valley in the immediate neighbourhood, hence their name of Killing Pits.

We may, therefore, surmise that these irregular pits on the edge of Goathland Moor were most probably formed for various purposes at very different periods, not solely for any one purpose, certainly not for dwellings.

THE ORIGIN OF SOME LINES OF SMALL PITS ON ALLERSTON AND EBBERSTON MOORS, NEAR SCAMRIDGE DYKES, IN THE NEIGHBOURHOOD OF SCARBOROUGH. BY J. R. MORTIMER.

(*Communicated 1st August. 1896*).

Various suggestions have been made by different persons, as to the origin of these pits, some from an antiquarian, others from a geological point of view.

Thus, Dr. Young, in his *History of Whitby* (published in 1817), page 676, after describing an extensive collection of pits, called "stone hags," on Blakey Moor, on the road between Castleton and Kirby Moorside, adds, referring especially to the Ebberston Common group, the subject of my paper :—

"Another cluster, similar to this, remains to be described. It is within the rabbit warren of Mr. M. Herbert at Scamridge, near Ebberston, where it occupies a space of about 500 yards, but not more than 50 broad, on a dry bank facing the east. The pits are generally smaller than those at Stone Hags, but, like them, are of various forms, chiefly oblong." He continues : "This remarkable cluster is surrounded by trenches that will afterwards be noticed; and it is observable that some of the trenches on Scamridge moor, and on the moors between that and Danby, have pits at regular distances on the sides of the trench." He then adds : "By this time the reader must be prepared for admitting the opinion that these excavations are the remains of human abodes of a very ancient date."

In the *Gentleman's Magazine* for 1865, Canon Atkinson also expresses this opinion ; and Canon Greenwell in the *Archæological Journal*, 1865, vol. xxii. p. 99, thus writes :

"We find in both districts the same mode of constructing the habitations ; for, though in the North Riding the foundation of the hut is generally a circular hollow, sunk in the surface of the ground, yet I have found near Ebberston, in connection with an entrance through the well-known Scamridge Dykes a number of hut-circles constructed in exactly the same manner as those so common in Northumberland."

This then, was the opinion entertained by antiquaries.

On the other hand, geologists, to whose views Canon Atkinson has since reverted, held that the pits were sunk in searching for ironstone. Mr. C. Fox Strangways, of the Geological Survey, supports this view in his Geological Memoir of this district; but in a letter to me, July 8th, 1893, he thinks the pits in this particular neighbourhood of "Red Dyke" may be natural sinkings of the surface.

In June, 1891, I first visited a short length of these pits nearest to Allerston; and again, in July, 1892, in company with Mr. Chadwick of Malton, without coming to any decision as to the purpose for which they had been made. I, therefore (June 14th, 1893), revisited the pits, and with the assistance of a labourer, removed from two of medium size (5 to 6 feet in diameter) the turf and soily matter which had accumulated in them.

At a depth of 3½ feet, we reached the original bottoms, which were roughly dish-shaped in form, and somewhat uneven. This time I walked the whole length of all the lines in the neighbourhood, examining most carefully each pit, and noticed that between those nearest to Allerston there was an undisturbed piece of ground, measuring 2 to 3 feet in width. I also observed that along this line the distance, measured from centre to centre of two adjacent pits, was from 9 feet to 10½ feet; whilst in the adjoining branch line to the west, the distance was from 12 to 13½ feet from centre to centre, very regular, where no after enlargement had been made. At some comparatively recent time, a few of the original pits appeared to have been deepened and lengthened in one direction. These enlarged pits were for a time perplexing, until I noticed that in some of them there stood a little water, and that in others rushes and tufts of water-grass were growing, indicating that they had recently contained water. I also observed that each of the largest and deepest of them had one long sloping side. These facts suggested to me that some of the original pits into which probably water had often filtered and remained for a time had, during dry periods, been enlarged and deepened by the farmers, as the readiest means of obtaining water for their cattle on these high grounds ; and that the sloping side was to admit of the cattle reaching the water. I believe this is now almost the only way of collecting such an important requisite for their live stock. This series of pits runs with its northern end into a somewhat shallow trench called "Wetmoor Dyke," so named most probably from the water which stands there in hollows on the surface more frequently than in other parts of the moor.

The next series of pits consists of two lines running northwards from "Ebberston common house," commencing a little over a mile N.E. of those just described. These I also carefully examined. In the southern end of the largest of these two excavated lines, the pits are very similar in appearance to those on Allerston Warren to the south ; but in proceeding northwards along the line, they were observed to increase in length and to run somewhat into one another. This tendency continued to increase till they finally formed a continuous *trench* before reaching the north end of a double entrenchment, which met them at right angles, and the two seem to end in one in the southern branches of "Deep Dale."

In venturing to comment on the two theories above referred to, I do not hesitate to remark that the pits on Allerston and Ebberston moors are mostly too small, and would have been very unsuitable for human habitations, as many of them in this immediate neighbourhood must have been, during the greater part of the year, half filled with water. The habitation hypothesis of the antiquary I cannot therefore endorse.

In regard to the speculations of the geologist, I have the presumption to say that there is no ironstone to be found on this moor near the surface, and, therefore, it is hardly likely that these numerous shallow excavations would have been made in searching for this material.

Equally unsatisfactory is the suggestion that they might be natural sinkings of the surface, for such would not have been so regular in line and distance from each other; moreover, such a cause would not account for the more or less raised bank which is visible on one, and sometimes slightly on both sides of the lines of pits.

Some other explanation must be given.

After my first visit in 1891, I mentioned those pits to Mr. Matthew Slater, of Malton, who had seen them and the extensive "Dykes" (entrenchments) in the same neighbourhood, during his botanical rambles on these moors, and he shrewdly suggested to me that they might be unfinished entrenchments.

Not until after my last and very careful inspection of the whole of the lines of pits, in June, 1894, was I fully convinced that Mr. Slater's suggestion was the right one, They are almost certainly the beginnings of lines of dykes, or entrenchments, which from some cause or other, were never completed. Their unfinished condition is a fortunate accident, as it gives us a key to the mode of proceeding in forming the extensive and puzzling entrenchments which traverse the moors and the Yorkshire wolds in every direction.

It would seem that, on planning the directions which the dykes were to take, a line of workmen were placed at regular distances with orders to commence work, and that after having so far penetrated the ground as to form the pits, the workmen in those particular sections, from some cause or other (probably, along one line, the wet nature of the ground, as previously stated) received orders to discontinue their work; hence the production of these rows of regularly placed pits and slightly raised banks which have so long perplexed alike the antiquary and the geologist. Certainly the long prevailing opinion that these lines of hollows on Allerston and Ebberston moors at least mark the sites of pit-dwellings or the shafts left in mining, must now be entirely given up.

In addition to these lines of pits, there are also on the moors, and in numerous places on the chalk wolds, very similar pits, but mostly in clusters. These also have often been erroneously named pit-dwellings; but, when carefully examined, they are in almost every instance found to have been formed by quarrying for ironstone, chalk, clay, or gravel, for building and other purposes during mediæval times, and up to the last century. Perhaps a few on the chalk wolds were made even as early as ancient British times, for the purpose of obtaining flints, which were used for making sling-stones, axes, and other rough tools and weapons.

While I reject, in the main, the village theory of these groups of pits, it must not be supposed that I entirely ignore the existence of the remains of pit-dwellings in Yorkshire, as, in several instances, I have discovered their undoubted remains in connection with some British barrows which I have opened. In my rambles on the moors, I have also observed pits which I thought were very probably the sites of scattered dwellings.

Surface appearances, however, are very unreliable proofs, as pits made for whatever purpose, after a few centuries, acquire from atmospheric and other causes a very similar outline ; and, therefore, the pick and the shovel in the hands of trained workmen, under experienced supervision, are the most reliable tests in solving such problems.

ON THE FOSSIL FISHES OF THE UPPER LIAS OF WHITBY. PART II.

BY ARTHUR SMITH WOODWARD, F.L.S., F.G.S., OF THE
BRITISH MUSEUM (NATURAL HISTORY).

PLATES XIX.-XXI.

Family EUGNATHIDÆ (continued).

CATURUS SP. IND.

Plate XIX.

Though not hitherto discovered at Whitby, the genus *Caturus* has already been recorded from the Upper Lias at Ilminster, Somersetshire, whence a fine specimen was obtained by the late Charles Moore.* The Upper Lias species, however, have not been precisely determined, and the two new specimens now to be described are unfortunately insufficient to display all the essential specific characters of the fish to which they belong. One of these is preserved in the Whitby Museum and the other in the York Museum, but neither shows much more than the crushed and imperfect head. The writer has not observed any other specimen.

The specimen in the Whitby Museum exhibits the head and abdominal region from the left side and partly from above; and the anterior half of the fossil is shown of the natural size in pl. xix., fig. 1. Of the cranium itself only the imperfectly preserved frontal bones are shown, each apparently as broad in front as behind, and the maximum width contained nearly three times in its length; the hinder half of the frontal is smooth, while its anterior half exhibits coarse radiating rugæ apparently due to irregularities in growth. Behind the cranium the displaced supratemporals are shown. That of the right side

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* A. S. Woodward, "Notes on the Collection of Fossil Fishes from the Upper Lias of Ilminster, in the Bath Museum." Proc. Bath Nat. Hist. and Antiq. Field Club, vol. viii., 1896, p. 235.

(fig. 1a) is proved to be twice as broad as its maximum length at the outer end, but is preserved chiefly in impression; the external face of the portion of the bone remaining is not ornamented by tuberculations. That of the left side (fig. 1, *p.t.*) is much fractured. Some of the characteristic cheek-plates are observable, but almost entirely as impressions of the inner face. The upper posterior suborbital (*s. o.* 1) is arched inwards above and is clearly deeper than its maximum width; but it is uncertain to what extent it was overlapped by the upper posterior circumorbital (*c. o.* 1), of which only a crushed fragment remains below. The lower posterior suborbital (*s. o.* 2) is a comparatively small plate, only about half as wide as the one above. The lower posterior circumorbital (*c. o.* 2) is completely shown, except at its anterior pointed extremity, and is twice as broad as deep. Merely a fragment of the maxilla (*mx.*) is preserved, with a few small slender teeth; but the long and narrow supramaxilla (*s. mx.*) is well displayed, attenuated and pointed in front, of nearly uniform depth in its hinder two-thirds, and gently rounded behind. The mandible (*md.*) is too obscure for description, but exhibits traces of relatively large conical teeth. The preoperculum (*p. op.*) is fragmentary, but displays the usual degree of expansion characteristic of the genus. The operculum (*op.*) is a little obscured above, but seems to have been almost as broad as deep. The breadth of the suboperculum (*s. op.*) is slightly more than twice the maximum depth of its exposed portion, and the well-preserved outer face of the bone is ornamented with an extremely delicate and closely arranged rugosity. Below the preoperculum are traces of the robust branchiostegal rays (*br.*), but the remainder of the branchiostegal apparatus is destroyed. The triangular supratemporal plate (*s. t.*) is partly exhibited in position, and four of the enlarged postclavicular scales (*p. cl.*) are displaced, but no other traces of the pectoral arch are recognisable. The endoskeleton of the trunk is not shown, and the scales, though preserved, are much abraded. None of these exhibit any markings beyond the concentric lines of growth; and the exposed area of those on the ventral aspect is distinctly equilateral, while that of the scales on the upper part of the flank is much deeper than broad.

The specimen in the Reed Collection, York Museum, is somewhat smaller than that just described, but seems to belong to the same species. It comprises the head, anterior abdominal region, and the base of the left pectoral fin ; but it is obliquely crushed from above, and thus much fractured and distorted. The frontal bones appear to be as already described. The squamosal, preserved on each side, exhibits only structural markings, and has a wide margin of overlap for the supratemporals, of which only fragments remain. The posterior upper suborbital is shown in impression on the left side and seems to resemble that of the first specimen in form and proportions; but the other cheek-plates are displaced and not sufficiently well preserved for description. A fragment on the right side exhibits the extremely delicate rugose ornament noted on the suboperculum of the previous specimen. The greater part of the maxilla is exposed on the right side ; it is shown to be very slender, very slightly arched, and not much deepened behind. The supramaxilla, partly shown on both sides, is shaped as in the first specimen. The mandible is complete, obscured in the coronoid region, but displaying its slender tapering form in front. The angular bone (pl. xix., fig. 2, *ag.*) is short and small ; the dentary (*d.*) clearly exhibits some of the teeth, those of the middle of the right side being long, not much expanded at the base, a little curved inwards or forwards at the apex (fig. 2a). Between the mandibular rami the large gular plate (*gu.*), chiefly in impression, is conspicuous, and this would extend about two-thirds the length of the mandible. The stout branchiostegal rays (*br.*) with traces of the longitudinal striations, remain in imperfect series behind. Those on the left side are best preserved, and seem to have been 18 in number. The opercular apparatus is too imperfect for description, and the pectoral arch is obscured ; but a large part of the base of the left pectoral fin (*pct.*) is preserved. The unjointed bases of 14 stout rays are shown, the foremost straight and marked with the characteristic longitudinal ribbing. The scales (*s.*) are marked only by the concentric lines of growth. Those of the ventral aspect (fig. 2, *s.*) are equilateral, while those of the upper part of the flank (fig. 2 b.) are considerably deeper than broad.

Family PACHYCORMIDÆ.

SAUROSTOMUS ESOCINUS, Agassiz.

Plate XX.

1833-44. *Saurostomus esocinus*, L. Agassiz, Poiss. Foss., vol. ii., pt. i., p. 14; pt. ii., p. 144, pl. lviiib., fig. 4.

1844. *Eugnathus giganteus* = *Pachycormus giganteus*, L. Agassiz, *ibid.*, pt. ii., pp. 104, 114 (undefined).

1844. *Pachycormus latirostris*, L. Agassiz, *ibid.*, pt. ii., p. 114.

1848. *Pachycormus esocinus*, C. G. Giebel, Fauna der Vorwelt, Fische, p. 197.

1848. *Pachycormus latirostris*, C. G. Giebel, *ibid.*, p. 198.

1848. *Eugnathus giganteus*, C. G. Giebel, *ibid.*, p. 238.

1858. *Pachycormus bollensis*, F. A. Quenstedt, Der Jura, p. 237, pl. xxxii., fig. 6.

(?) 1878. *Pachycormus westermani*, T. C. Winkler, Archiv. Mus. Teyler, vol. v., p. 9, pl. i.

1891. *Caturus gigas*, H. E. Sauvage, Bull. Soc. Hist. Nat. Autun, vol. iv., p. 74, pl. vii.

1895-96. *Pachycormus* (*Saurostomus*) *esocinus*, A. S. Woodward, Catal. Foss. Fishes, B.M., pt. iii., p. 388; and Proc. Bath Nat. Hist. and Antiq. Field Club, vol. viii., p. 241.

Type: Dentary bone of fish.

Among the numerous ganoid fishes mentioned though not described by Agassiz in his great work, is a large member of the family Pachycormidæ, which he records under the name of *Pachycormus latirostris*. The only brief notice of this fish is as follows:—"Très grande espèce, plus grande que le *P. macropterus*, mais à tête courte et à museau pointu. Du lias de Whitby." No further account of the species has hitherto been published, but the original specimens on which it was founded in the Enniskillen and Egerton Collections, are now in the British Museum, and it is thus possible to determine exactly what Agassiz meant by the name in question. Careful comparison seems to show that a detached mandible which he had previously described from the Upper Lias of Baden under the name of *Saurostomus esocinus*, truly belongs to the same fish. Comparatively well-preserved specimens from the same horizon in Würtemberg, and also evidently indistinguishable, have subsequently been named *Pachycormus giganteus* and *P. bollensis*, while an identical detached head from the Upper Lias of Yonne, France, is described and figured by Sauvage (*loc. cit.*) under the name of *Caturus gigas*. Of all the names mentioned, that of *Saurostomus esocinus* is the earliest, and this must therefore be used for the Whitby fish, unless (as some authors have done) we change it to *Pachycormus esocinus*. The latter, however, is probably an undesirable emendation ; for it will be noticed that the roof of the skull is quite flat, not raised into a median ridge at the back, while its constituent bones are less completely fused together than in the typical *Pachycormus*. We may also add that the "lateral line" on the tail in a fine specimen from Ilminster, in the Moore Collection, Bath, is supported by a row of somewhat enlarged scales, such as have never been observed in any undoubted species of *Pachycormus*.

The specimens in the British Museum, labelled *Pachycormus latirostris* by Agassiz, comprise (i.) an imperfect head with opercular apparatus, (ii.) a very imperfect vertically crushed specimen of the same with its pectoral fins, and (iii.) a detached pectoral fin, all from the Enniskillen Collection. A fractured nodule with remains of the head and pectoral fin, in the Egerton Collection, is also similarly labelled by the late Sir P. de M. Grey Egerton.

The first specimen (No. P.3708) is important, and is shown of two-thirds the natural size in pl. xx., fig. 1. This represents the right side of the fossil completed by the addition of the operculum from the opposite side. Fig. 1a, of the natural size, shows part of the anterior dentition which may be premaxillary, though the bone is obscured by matrix. The greater part of the fossil is much obscured by intractable matrix. In front of a transverse fracture across the anterior frontal region, the snout is crushed downwards ; but the remarkably obtuse appearance (*r.*) in side view may be misleading, only matrix being exposed here. The roof of the skull is nearly flat, with a slight median depression, and no elevation in the occipital region. The small parietals can be distinguished meeting in the middle line, ornamented with very fine tubercles and rugæ disposed along the radiating lines of growth. An impression of the squamosal on the left side shows that it was larger than the parietal element; the frontals are very large and exhibit traces of a fine ornamentation resembling that of the parietals. The sclerotic (*scl.*) is ossified, and there are fragments of finely tuberculated cheek-plates. Traces of the hyomandibular (*hm.*) on both sides are too imperfect for description. The maxilla (*mx.*) is also a mere fragment, but it bears some small slender teeth. The anterior teeth (fig. 1a) are similarly slender but larger, and extend in a continuous spaced series round the obtuse end of the fossil which represents the rostrum. These teeth are round in section and smooth, only exhibiting a few vertical folds at the base; and they may belong either to the premaxilla or to an inner element. The mandible tapers to the symphysis, and its outer face exhibits a conspicuously fibrous texture. Nearly the whole of the outer face of the ramus is formed by the dentary (*d.*), only a very small angular (*ag.*) appearing behind. The coronoid region is obscure, and so is the dentition; but there are indications of a series of large teeth on the anterior part of the dentary on both sides, and some minute teeth within on the left side probably belong to the splenial. The preoperculum (*p. op.*), well shown on the right side and partly also on the left, is a much-expanded unornamented bone, marked by the concentric and radiating irregularities of growth; its exposed portion does not extend to the top of the cheek. The operculum (*op.*), nearly perfect only on the left side, is trapezoidal in form, widest below, and its maximum width slightly exceeding the depth. The bone is not flat, but considerably curved inwards postero-superiorly; and as on the preoperculum, the structural lines form its only ornament Below the operculum there are merely fragments of the other plates, notably a few traces of branchiostegal rays on the right side. The left post-temporal projects a little out of the matrix behind the cranial roof.

The second specimen in the Enniskillen Collection (Brit. Mus., No. P.3709) is very unsatisfactory, but evidently belongs to the same species as the above, and shows that the detached pectoral fin (No. P.3709a) is correctly placed here. This fin (pl. xx., fig. 2) is long and narrow, with about ten stout rays and others behind, all unarticulated for the greater part of their length, but very finely divided distally. Some of the stouter rays exhibit feeble transverse wrinkles near the proximal end. Behind the head there are scattered remains of the very delicate arches of the vertebral axis. They are filled with spar in the fossil, and must thus have been only imperfectly calcified.

The nodule in the Egerton Collection (No. P. 2039) displays the fragmentary remains of the right side of the head and opercular apparatus from within. It shows that the suboperculum is much broader than deep, and is succeeded below by a long series of branchiostegal rays which extend forwards to the place that would be occupied by the gular plate. These cannot be counted easily, but are more than twenty in number.

No less imperfect specimens of this fish are known from Whitby, and it is thus necessary to depend upon those from Ilminster and Würtemberg for a *diagnosis of the species.* This may be attempted as follows :—

A species attaining a length of not less than one metre. Head with opercular apparatus occupying one-quarter of the total length of the fish ; head very short and stout, its length equalling about two-and-a-half times the width of the operculum. Cranial roof-bones and cheek-plates ornamented with fine delicate tubercles, usually arranged along the lines of growth ; teeth slender and incurved at the point, round in section, smooth and only exhibiting a few vertical folds at the base. Operculum trapezoidal in form and the upper border shortest, its maximum width about equal to its depth, and the outer face marked only by lines of growth ; preoperculum similarly marked ; branchiostegal rays somewhat less than forty in number. Dorsal and anal fins about equally extended, with not less than thirty rays, the latter arising just in advance of a point opposite the hinder end of the former. Scales smooth, those of the "lateral line" on the caudal region somewhat enlarged.

PACHYCORMUS CURTUS, Agassiz.

Plate XXI., fig. 1.

1832. *Uræus gracilis*, L. Agassiz, Neues Jahrb., p. 142.

1833-44. *Pachycormus gracilis*, L. Agassiz, Poiss. Foss., vol. ii., pt. i., p. 12 ; pt. ii., p. 114 (undefined).

1844. *Pachycormus curtus*, L. Agassiz, *ibid.*, pt. ii., p. 112, pl. lix

1844. *Pachycormus latus,* L. Agassiz, *ibid.*, pt. ii., p. 114.
1843-58. *Pachycormus curtus,* F. A. Quenstedt, Flözgeb. Würtemb., p. 244 ; Der Jura, p. 235, pl. xxxii., fig. 4.
1860. *Pachycormus curtus,* A. Wagner, Gelehrt. Anz. k. bay. Akad. Wiss., vol. 50, p. 225.
1895. *Pachycormus curtus,* A. S. Woodward, Catal. Foss. Fishes, B. M., pt. iii., p. 385.

Type: Imperfectly preserved fish from Whitby ; British Museum.

Remains of the true and typical *Pachycormus* itself are tolerably common in the Whitby Lias, and four species were recognised by Agassiz. Only one of these species, however, has hitherto been described, and even the original diagnosis of this form is in many respects inadequate and misleading. It is named *Pachycormus curtus* in reference to its comparatively shortened head and trunk, and the type specimen is preserved in the counterpart halves of a nodule now in the British Museum.

This fossil, numbered P.464 and P.3698, represents a fish about 0·27m. in length. The general form and proportions of the trunk are shown by the margin of the squamation ; but the abdominal region is a little deepened by crushing, as indicated by the displaced scales in front of the dorsal fin and behind the pectorals. The skull is a little deflected to the left, so that the remains of the cranial roof are shown on the side figured by Agassiz (*loc. cit.*), while an imperfect supratemporal (or perhaps post-temporal) is seen above the opercular bones. The latter are much fractured, and no distinction is made between cracks and sutures in the figure. The operculum is best shown on the counterpart ; it is triangular in form, with rounded postero-inferior angle, and its maximum depth only slightly exceeds its greatest width at the base. The suboperculum is more obscure, but seems to be two-thirds as deep as the operculum ; and there are traces of branchiostegal rays below. The original description of the trunk is evidently based on Dinkel's misleading figure. The few remaining neural and hæmal arches are much more slender than indicated, as also are the supports of the anal fin, which are shown by other specimens to be equal in number to the dermal rays. All these elements exhibit their usual hollowness in the fossil, having been only superficially calcified. The hæmal arches at the base of the tail are comparatively stout, and there are traces of the great triangularly-expanded hæmal already noted by Quenstedt* in specimens of *Pachycormus* from Boll. So far as they can be observed, the scales are smooth and of tolerably uniform size, some longer than deep near the ventral border. There is also a fragment of the enlarged median scale at the origin of the anal fin.

A specimen preserved in shale, in some respects more satisfactory, is shown of the natural size in pl. xxi., fig. 1. The general proportions of the fish are here probably well indicated, but the head and pectoral region are a little crushed upwards, so that the right mandibular ramus and base of the pectoral fin are exhibited considerably above those of the left side. The head and opercular apparatus, however, are too imperfect for detailed description. The axial skeleton of the trunk is obscured by the scales of the abdominal region, but a few delicate ribs are seen in its hinder portion. The remarkably short, much inclined neural and hæmal arches in the caudal region exhibit the internal hollow filled with spar, while those at the base of the caudal fin are thickened as usual, and the axis is disturbed just in front of the latter. The long and narrow pectoral fin is well preserved on the left side, though with imperfect anterior border; it exhibits about twenty-one rays, mostly broad, all divided and articulated at the distal end. There is no trace of pelvic fins. The dorsal fin is somewhat crushed and imperfect distally. It arises slightly in advance of the middle point between the occiput and the base of the caudal fin, and is borne by at least thirty supports, which are more or less disturbed and fractured, and show an internal axis of spar. The anal fin is slightly more than twice as distant from the pectorals as from the caudal, and appears to display its true form with the anterior acumination, though the rays are obscured in the middle by a longitudinal streak of matrix. Its supports are about twenty-five in number, each with an internal core of spar; and those situated anteriorly are the longest, while those in the hinder half of the fin can be observed to correspond exactly in number with the rays they support. The caudal fin is apparently complete, though obscure. The squamation is only imperfectly preserved, and the enlarged anal scale is fragmentary.

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* F. A. Quenstedt, Der Jura, p. 236, pl. xxxii., figs. 3, 4.

The fish just described is of the form named *P. gracilis* by Agassiz, as is indicated by a specimen in the Enniskillen Collection (No. P.3711) bearing his label, and by another in the Egerton Collection (No. P.885), of which he signed the label. The first of these specimens is much elongated by crushing, while the other is similarly deepened ; but they appear to agree with *P. curtus* in all characters which can be compared. The operculum of No. P.3711 is shown to be triangular in shape and slightly deeper than broad ; both exhibit delicate ribs, and the second also free neural spines in the abdominal region. These neural spines, however, are better seen in another specimen in the British Museum (No. P.2037), which seems to show also free atrophied fin-supports above them.

The type specimen of the so-called *Pachycormus latus* in the Enniskillen Collection (Brit. Mus., No. P.3699) is too imperfect for determination, but seems to represent merely a large individual of *P. curtus*, nearly twice as large as the ordinary individuals of the latter. It is curiously restored after the manner of the Whitby dealers, the counterpart of the pectoral fin being fixed above the head, and other fragments of the counterpart being worked into the lower portion of the caudal region. It wants the end of the snout and the anal and caudal fins. The dorsal fin is also very imperfect. The remains of the head and opercular apparatus suggest the proportions of *P. curtus*, and the scales appear remarkably large because they are scattered and not in their regular overlapping sequence. The comparatively upright direction of the neural spines in the front half of the caudal region probably implies deepening of the trunk by distortion.

The original description of the type specimen of *Pachycormus curtus* being in some respects misleading, as already remarked, it is not surprising that the species has been misunderstood, while French Upper Liassic specimens, which most likely belong to it, have received distinct names.* The classification of the species of

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* H. E. Sauvage, Bibl. Ecole Hautes Etudes, vol. xiv. (1875), No. 1, and Bull. Soc. Sci. Yonne [3], vol. vii. (1883), pp. 41-46, pl. ii.

Pachycormus, however, is still very unsatisfactory, and even the following *specific diagnosis*, chiefly based on the material now described, must be regarded as only of provisional value :—

A stout species of moderate size, attaining a length of about 0·5m. Head much shorter than in the type species, *P. macropterus*, and this with the opercular apparatus occupying more than one quarter of the total length of the fish ; operculum triangular, deeper than broad, and branchiostegal rays about 40 in number. Dorsal fin with about 30-35 rays, arising just in advance of the middle of the back ; anal fin with about 25 rays, and its origin slightly more than twice as distant from the pectorals as from the caudal. Scales of moderate size and smooth.

PACHYCORMUS ACUTIROSTRIS, Agassiz.

Plate XXI., figs. 2-4.

1844. *Pachycormus acutirostris*, L. Agassiz, Poiss. Foss., vol. ii., pt. ii., p. 114.

1895. " " A. S. Woodward, Catal. Foss. Fishes, B.M., pt. iii., p. 384.

Type : Imperfect head ; British Museum.

Some detached heads of *Pachycormus* from the Whitby nodules were named *P. acutirostris* by Agassiz ; but this species has never been defined, and the original record of the name is only accompanied by the brief statement :—" Espèce à museau pointu, à dents fines et très acérées." These fossils not improbably belong to the typical species *P. macropterus*, but in the absence of conclusive proof it seems best to retain the name by which they have hitherto been entered in catalogues and lists. Their great interest consists in the features of cranial osteology they exhibit.

One of the best examples of these heads in the British Museum (No. P. 3705a) is labelled by Agassiz as intended for a type specimen. It is shown of the natural size from the left lateral aspect in pl. xxi., fig. 2, the gular plate being added in fig. 2a. The bones are much fractured and flaked, while most of those of the right side are buried or broken away, and the large postero-inferior suborbital is thrust forwards. The form of the snout is deceptive, the actual bone having been for the most part removed and an impression of its inner face alone remaining. Further back the cranial roof is preserved on the left side, and where the outer face can be observed it is shown to be very finely granulated. The hinder region of the cranial roof is raised in the manner characteristic of the genus ; while the sutures between the frontal, postfrontal, and parietal elements can be distinguished as shown and described in the next specimen below. The indent along the base of the triangular occipital eminence is also conspicuous on the left side. The form of the two large postorbital cheek-plates is almost completely shown, but the actual bone is preserved only in patches. Where the outer surface remains it is ornamented with very fine, closely arranged and flattened rugæ and tuberculations, which exhibit a tendency to radiation at the margins. The impression of the inner surface of these plates seems to bear the imprint of numerous vascular pores ; and the well-preserved suborbital already mentioned on the right side shows that these pores penetrate to the outer face of the bone. The upper posterior suborbital (*s. o.* 1) is trapezoidal in shape, a little broader than deep, and sharply bent inwards above. The lower posterior suborbital (*s. o.* 2) is almost triangular in shape, the apex turned forwards and partly excavated. The remainder of the cheek is so much fractured that fragments of only four plates of the circumorbital series (*c.o.*) are observable behind the eye. These, as usual, are small and must have been much broader than deep. One shows an extremely fine superficial granulation. The ossified sclerotic (*scl.*) is also imperfectly preserved. The long, slender maxilla (*mx.*) is shown in fragments, very finely rugose externally, and bearing traces of small, stout, smooth teeth. The form and proportions of the left mandibular ramus are indicated, but the teeth and the outer surface of the bone are almost completely destroyed. The limits of the relatively large dentary (*d.*) and the small angular (*ag.*) are approximately indicated by the direction of the structural lines of growth. The gular plate is well preserved, of the form and proportions indicated in fig. 2a, but the bone itself is much flaked. It seems to have been ornamented with radiating rugæ as fine as those of the other external elements. The branchiostegal rays are represented only by the merest fragments ; but the displaced operculum is nearly complete and shown to be as broad as deep.

A second specimen in the British Museum (No. P.884b) exhibits the opercular and branchiostegal apparatus and a great part of the cranial roof. The outer cranial bones are not so much flaked as in the last specimen, and the fine granular ornament is beautifully displayed. The total length of the skull must have been twice as great as its maximum width, and the snout, though imperfect, is shown to have been remarkably acute. There is no trace of a median frontal suture, while it is not clear where the frontals end and the dermal ethmoidal armature begins. The long and narrow post-frontal, however, is distinct on the left side, extending from above the middle of the orbit to the front border of the posterior suborbitals. The wavy and well-defined hinder border of the frontal element is conspicuous on the left side, not so far back as that of the post-frontal, directly transverse on the lateral part of the skull, directed somewhat forwards as it is traced up the side of the median triangular eminence. The whole of this border is in contact with the parietal, which is of longest extent in its flattened outer lateral portion and becomes narrowed as it rises to meet its fellow of the opposite side in the median eminence. This line of meeting is unfortunately broken and displaced. The squamosal seems to have been removed and destroyed. The fragmentary remains of the cheek do not add anything to the information obtained from the previous specimen, except that the large supramaxillary plate is indicated at the back of the maxilla on each side. This element, however, is better shown in the next specimen. The opercular apparatus is more worthy of description, and that of the left side is shown of the natural size in pl. xxi., fig. 4. The operculum (*op.*) is triangular in shape, and seems to be about as deep as broad, the preoperculum being obviously displaced somewhat backwards and covering its anterior border. The suboperculum (*s. op.*) is irregularly rhombic in shape and much broader than deep, but the preoperculum also covers an undetermined extent of its anterior border. Both these bones are much abraded, but show distinct traces of the characteristic external ornamentation. The preoperculum (*p. op.*) is semi-lunar in form, much extended, and shown by the remains on both sides of the fossil to have been flattened, without any strong ridges, and marked only by the fine rugose ornament, with certain small radiating canals, which may have been either sensory or vascular. The left preoperculum, represented in the figure, is much flaked, exposing an extensive impression of its inner face. No interoperculum is visible, and it must have been relatively small if ever present. The two uppermost branchiostegal rays (*br.*) are considerably larger than the others. The series is too imperfect for counting, but the fine external ornament is observable on all of them. The gular plate is also displaced and fractured, though evidently of the usual large proportions. Behind the skull and above the operculum may be seen remains of the supratemporal and supraclavicular plates, the latter element very deep and narrow. There are also finely rugose scales beyond these bones, nearly all slightly deeper than broad in their exposed portion.

Another specimen labelled "*Pachycormus acutirostris*, Agass." by Agassiz (No. P.3705b) is more imperfect than those just described, but interesting as exhibiting the jaws and teeth in a somewhat better state of preservation. Those of the left side are shown of the natural size in pl. xxi., fig. 3. The supramaxilla (*s. mx.*), preserved in its natural position on the right, slightly displaced on the left, is an oval plate of bone, three times as long as its maximum depth, and marked externally with a very fine rugose ornament. It overlaps the maxilla (*mx.*), which is exposed in a narrow strip beneath and exhibits the same ornamentation. This bone appears to have been a little more than three times as long as the supramaxilla, and it gradually tapers forwards from the anterior end of the latter element. Its small conical teeth are smooth and slightly incurved, and the series on the right side is shown to extend backwards just beyond the point of overlap of the supramaxilla. The premaxilla is unfortunately wanting on both sides. The mandible, though much fractured, is best preserved on the left, and the anterior half of the dentary (*d.*) bears a close series of teeth similar to those of the maxilla, but somewhat larger than these. It may also be added that some of the small equilateral scales behind the branchiostegal rays are well preserved in this specimen, and are very finely marked with a rugose ornament in their exposed portion.

The trunk of the fish to which these heads belong is still too imperfectly known for satisfactory comparison with *P. macropterus*, and they are only retained provisionally separate from the last-mentioned species because they seem to exhibit a slightly shorter snout.

Explanation of Plates.

Plate XIX.

Fig.		Page.
1.	*Caturus* sp. ind. ; left lateral aspect of head and opercular apparatus. *br.*, branchiostegal rays ; *c.o.* (1 and 2)., circumorbitals ; *md.*, mandible ; *mx.*, maxilla ; *op.*, operculum ; *p.cl.*, postclavicular scales ; *p.op.*, preoperculum ; *p.t.*, post-temporal ; *s.mx.*, supramaxilla ; *s.o.* (1 and 2)., suborbitals ; *s.op.*, suboperculum ; *s.t.*, supratemporal. [Whitby Museum.]	155
1*a*.	Right post-temporal plate of same specimen.	155
2.	*Caturus* sp. ind. ; lower aspect of head, etc. *ag.*, angular ; *br.*, branchiostegal rays ; *d.*, dentary ; *gu.*, gular plate ; *pct.*, pectoral fin ; *s.*, scales. [York Museum.]	157
2*a*.	Mandibular teeth of same specimen, twice natural size.	157
2*b*.	Upper flank-scales of same specimen.	157

Plate XX.

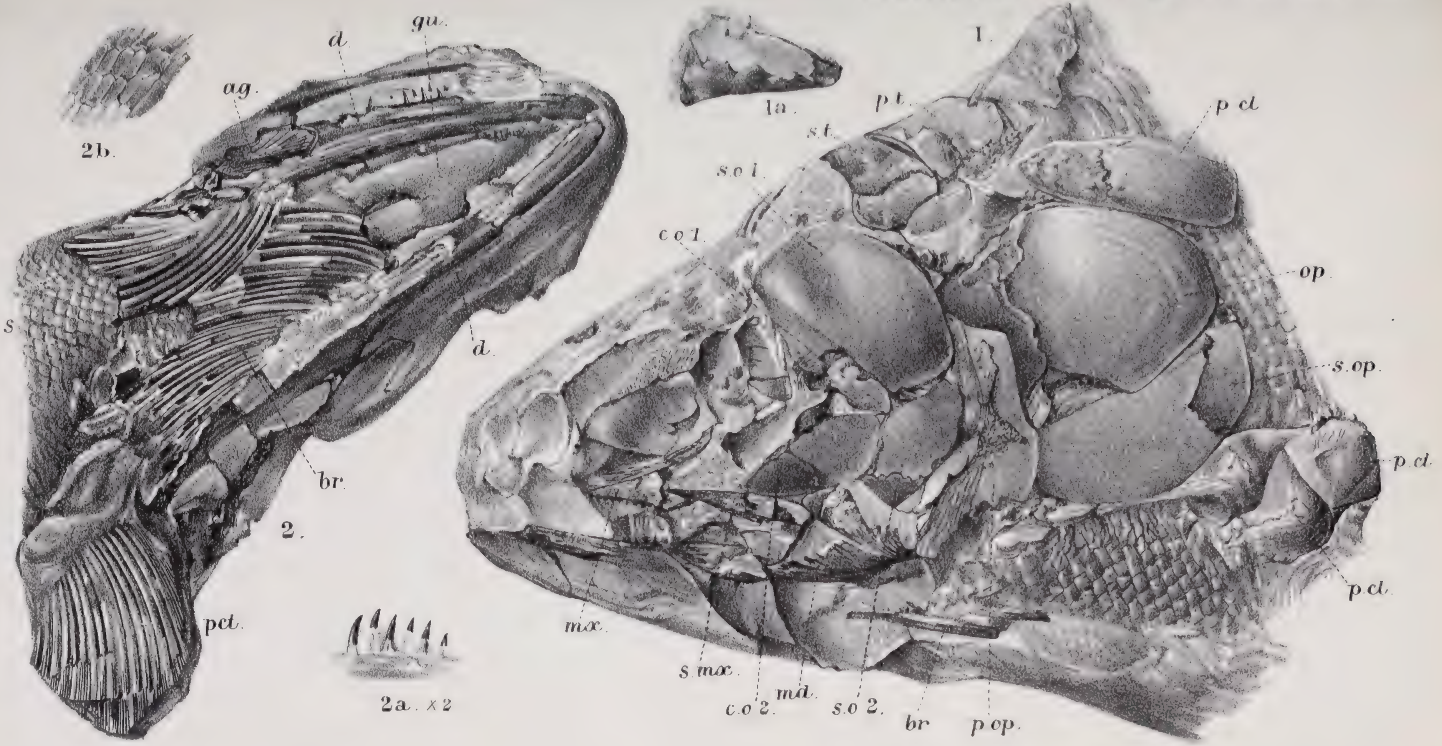
1.	*Saurostomus esocinus*, Agassiz ; head and opercular apparatus, right lateral aspect, two-thirds natural size. *ag.*, angular ; *d.*, dentary ; *hm.*, hyomandibular ; *mx.*, maxilla ; *op.*, operculum ; *p.op.*, preoperculum ; *r.*, crushed rostrum ; *scl.*, sclerotic. [P. 3708.] ...	159
1*a*.	Anterior upper teeth of same specimen, seen from front aspect.	160
2.	*Saurostomus esocinus*, Agassiz ; pectoral fin, two-thirds natural size. [P. 3709*a*.]	160

Plate XXI.

1.	*Pachycormus curtus*, Agassiz ; right lateral aspect of fish, slightly distorted. [P. 3710.]	163

Fig.		Page.
2.	*Pachycormus acutirostris*, Agassiz ; head, left lateral aspect. *ag.*, angular ; *c.o.*, circumorbitals ; *d.*, dentary ; *mx.*, maxilla ; *s.o.* (1 and 2)., suborbitals ; *scl.*, sclerotic. [P. 3705*a.*]	165
2*a.*	Gular plate of same specimem.	166
3.	*Pachycormus acutirostris,* Agassiz ; jaws of left side. *d.*, dentary ; *mx.*, maxilla ; *s.mx.*, supramaxilla. [P. 3705*b.*]	168
4.	,, ,, left opercular apparatus. *br.*, branchiostegal rays ; *op.*, operculum ; *p.op.*, preoperculum ; *s.op.*, suboperculum. [P. 884*b.*]	167

Note.—All the specimens represented on Plates xx. and xxi. are preserved in the British Museum, and the numbers in square brackets refer to the Register of the Department of Geology. Unless otherwise stated, the figures are of the natural size.



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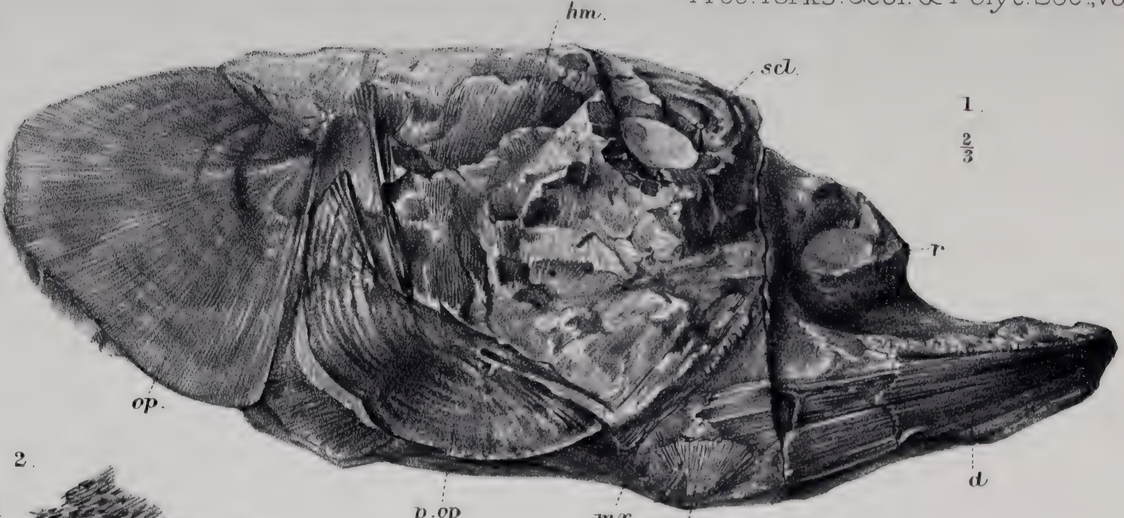
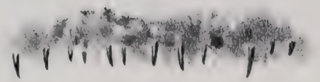
CATURUS.

1.

2/3

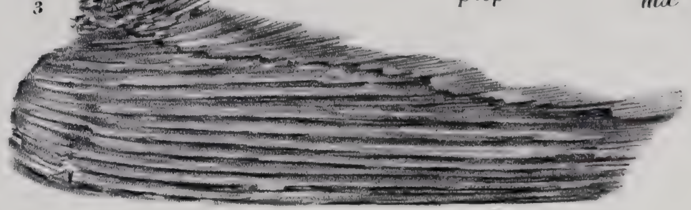




1a.

2.

2/3



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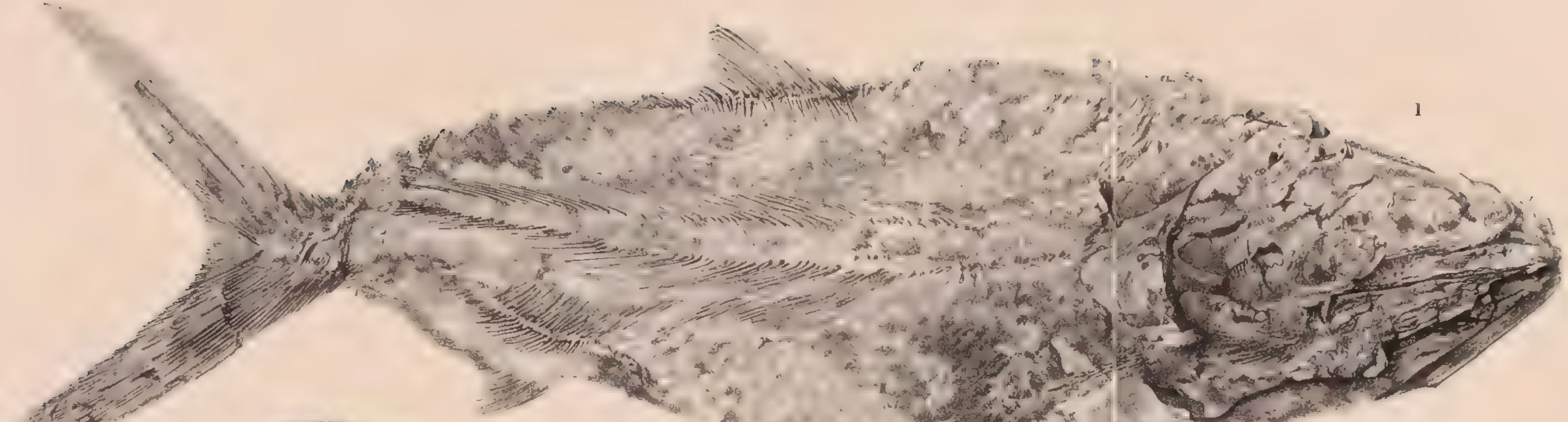
SAUROSTOMUS.

1



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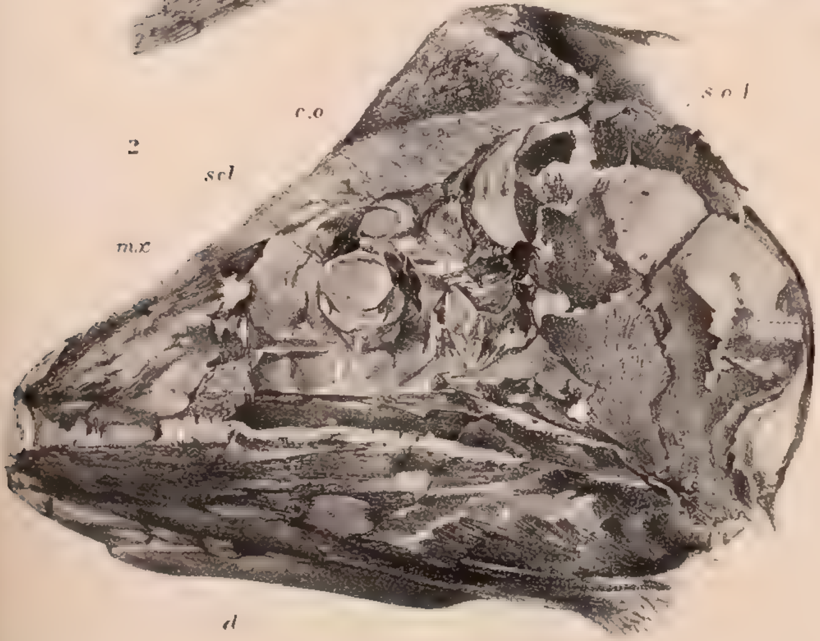

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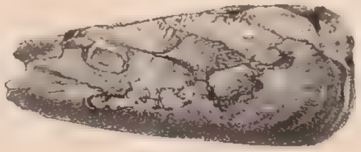

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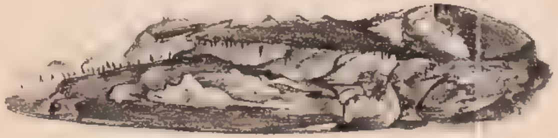

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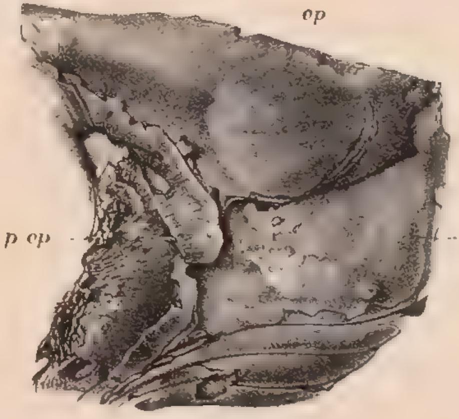

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PACHYCORMUS

NOTES ON THE WHITE CHALK OF YORKSHIRE. PART III. THE GEOLOGY OF FLAMBOROUGH HEAD, WITH NOTES ON THE YORKSHIRE WOLDS. BY G. W. LAMPLUGH, F.G.S., OF H.M. GEOLOGICAL SURVEY.

PLATES XXII. TO XXXIV.

As a subject for systematic illustration no part of the Yorkshire Coast is more fitting than Flamborough Head, in which bold simplicity of outline is united with such wealth of picturesque detail as to render the result satisfactory from an artistic as well as from a scientific standpoint. The views here reproduced are from a series of beautiful photographs taken by Mr. Godfrey Bingley, who deserves the warmest thanks of the Society for the admirable judgment as well as for the high technical skill which he has brought to bear on their preparation. Arranged in sequence, they embrace practically the whole of the northern coast line of the headland, from Speeton to the eastern extremity under the Lighthouse. The sketch-map (page 172) of the promontory was prepared to accompany a paper by the writer on the White Chalk of Yorkshire, published in the last volume of their Proceedings,* but was inadvertently omitted. It will serve to show the geographical features of the headland, and to indicate the position of the places illustrated by the photographs.

To any one acquainted with the outlines of the geology of the Yorkshire Coast this panoramic representation tells its own story. I propose, however, to take advantage of the opportunity, while describing the views, to write out a few notes on the physical features of a region so well known to me.

Flamborough Head shows the intersection of the Chalk formation by the waters of the North Sea. Northward from the shores of the English Channel the Chalk has extended continuously, save where broken by the Wash and the Humber, to this point. Here the low rolling hills so characteristic of the formation are abruptly truncated to form the promontory, while to the north of it the wide

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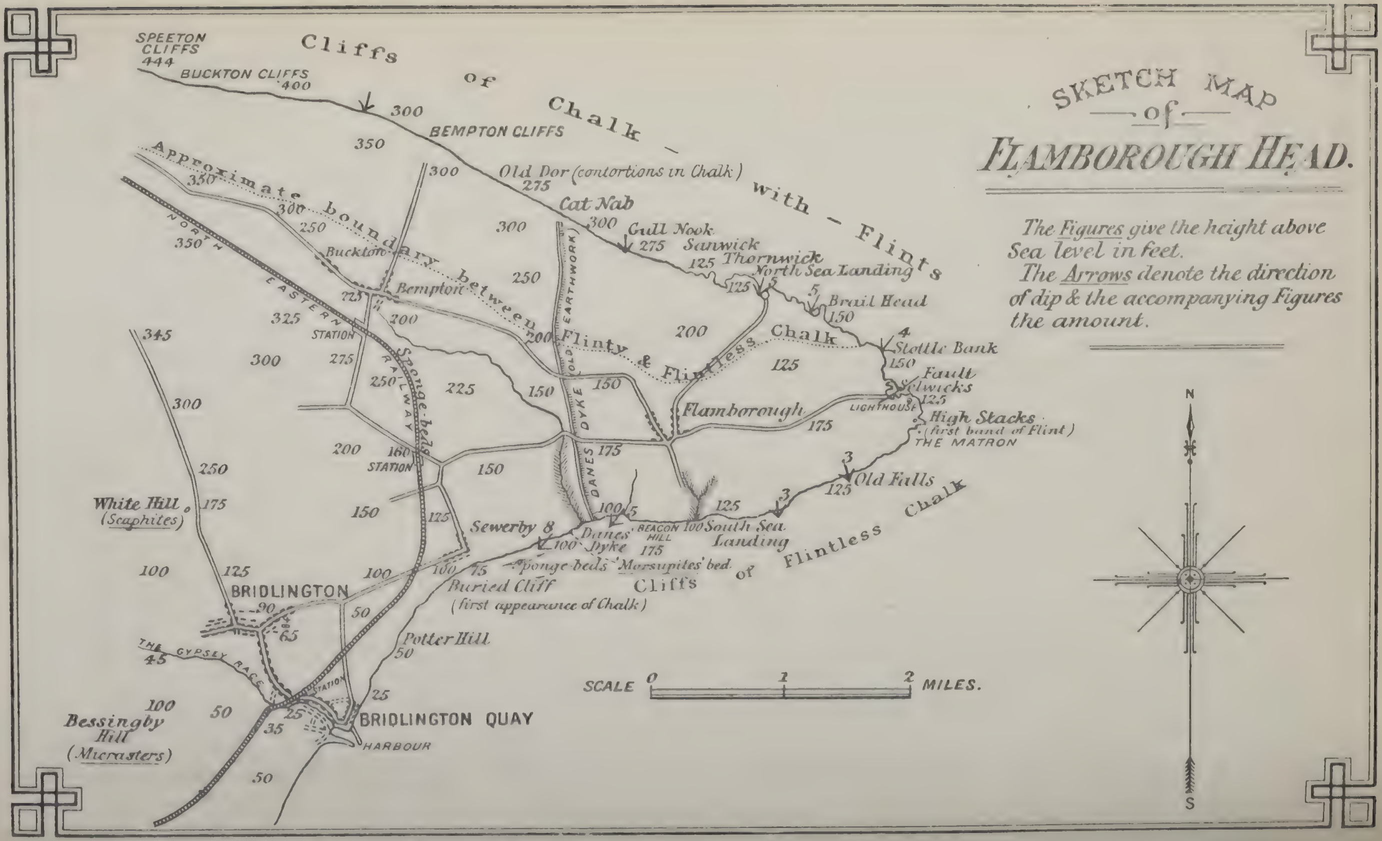
* Notes on the White Chalk of Yorkshire, parts i. and ii. Proc. Yorksh. Geol. and Polyt. Soc., vol. xiii., p. 65 (1895).


SKETCH MAP of FLAMBOROUGH HEAD.
The Figures give the height above Sea level in feet.
The Arrows denote the direction of dip & the accompanying Figures the amount.
Cliffs of Chalk — with — Flints
Approximate boundary between Flinty & Flintless Chalk
Cliffs of Flintless Chalk
SPEETON CLIFFS 444
BUCKTON CLIFFS 400
BEMPTON CLIFFS
Old Dor (contortions in Chalk)
Cat Nab
Gull Nook
Sanwick
Thornwick
North Sea Landing
Brail Head
Stottle Bank
Fault
Selwicks
LIGHTHOUSE
High Stacks (first band of Flint)
THE MATRON
Old Falls
South Sea Landing
BEACON HILL
Danes' Dyke
DANES DYKE (OLD EARTHWORK)
Sewerby
Sponge-beds
'Marsupites' bed
Buried Cliff (first appearance of Chalk)
Potter Hill
Flamborough
Buckton
Bempton
NORTH EASTERN RAILWAY
STATION
BRIDLINGTON
BRIDLINGTON QUAY
HARBOUR
THE GYPSEY RACE
White Hill (Scaphites)
Bessingby Hill (Micrasters)
SCALE 0 1 2 MILES.
N
S

Proc. Yorksh. Geol. & Polyt. Soc., Vol XIII.

recess of Filey Bay and the broad low Vale of Pickering mark the emergence of the Lower Cretaceous and Upper Jurassic Clays from beneath the Chalk escarpment. The indentation to the southward of the headland is due partly to the less resistant nature of the uppermost portion of the Chalk itself as compared with the lower, and partly to the great curve which occurs in the strike of the strata after entering Yorkshire.

PART I. DESCRIPTION OF THE PHOTOGRAPHS.

1. SPEETON GAP.

The first of the photographs shows the cliff at Speeton where the Lower Cretaceous Clays emerge from beneath the Chalk. The point of view is near low-water mark on the shore opposite the mouth[*] of the little ravine known as Speeton Gap, looking southward. To facilitate the explanation of this plate (and also of Nos. 2 and 12) an outline key on a reduced scale is given in Plate xxxiv. to which reference should be made. The low ridge in the foreground to the right of the ravine is composed entirely of Speeton Clay (*Division B.* ; *Zone of Bel. Brunsvicensis*). The ground to the left of the gully is made up of displaced masses of White and Red Chalk (with a thick capping of Glacial Drift) which have come down over the slippery surface of the Speeton Clay. Some of these slips probably date back to Preglacial times, as they appear to be truly overlapped by the boulder-clay and gravels. These old slips form the higher portion of the slope in the background of the picture. Sometimes huge masses like that forming the terrace in the middle distance are brought down, but there is, besides, a constant crumbling and sliding forward of all the material overlying the clay, especially in wet weather, with a glacier-like motion, and the lower slopes are constantly "crevassed" by small fissures, while the likeness of the sliding masses to little glaciers is further borne out by the large boulder-like blocks which are carried forward, and by the ridge of sand and shingle sometimes pushed up by them where they extend to the shore. Sliding ground of this character is well shown in the low slope in the middle of the picture. The uppermost beds of the Speeton Clay, more or less displaced, are revealed in places just above high-water mark on the left side of the photograph where the slips have been partially removed by the waves.*

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[*] Called "Bulltongue Nook" on the new 6-inch Ordnance Map (Sheet cxi., S. W.)

2. Speeton Cliffs.

It is from a point on the slipped undercliff just described, about 250 yards distant from Speeton Gap, looking eastward, that the admirable photograph reproduced in Plate 2 has been secured. No picture, whatever the medium, can do any justice to the beauty of this scene, which to my mind is unsurpassed on any of our shores. The severity of the great precipice, rising overhead buttress after buttress in majestic perspective, is only part of the charm. It is the delicacy of colour always pervading the scene that appeals so strongly to the beholder. The flinty chalk of these cliffs takes on under the weather a soft clear tint of pearly grey, amid which lie slopes and ledges of pallid green where a shadow-loving grassy or mossy growth exists. Above are the darker drift slopes, ruddy-brown where naked, and of a full green where overgrown. Below there is a sinuous beach of chalky pebbles of dazzling whiteness, edged at low-water with spreads of russet sand and sombre weedy rocks, and then the great shining plain of the shallow grey-blue sea. In the foreground there are patches of red chalk and of dark blue clay among the slips ; and in the springtime a plentiful sprinkling of primroses. Indeed a scene to be remembered with enthusiasm !

As for its geological features, which are shown on the key plate, these also are full of interest. The character of the slipped undercliff in the foreground has already been described. The Speeton Clay occupies the foreshore quite as far as the group of loose rocks at half-tide level which are seen in the middle-distance of the picture, but exposures of it on this part of the shore are of very rare occurence. The Red Chalk is seen in slips all along the base of the undercliff, and this is perhaps the best collecting ground for its fossils. It occurs in place, or only slightly displaced, on the shore above half-tide level, just beyond where the rocky beach is seen ; and is well exposed in section at the base of the cliff two or three hundred yards farther east, opposite the place where the water indents the rocky foreshore in the photograph.

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* Fuller details regarding the Speeton Clay will be found in papers by the author, in Quart. Journ. Geol. Soc., vol. xlv., p. 575, and vol. lii., p. 179, wherein also the bibliography of the locality is given.

The thickness of the Red Chalk proper in this section is about 30 feet, but at several higher horizons in the Lower Chalk there are red or pink bands, the highest being fully 80 feet above the basement bed.

The thickness of the Lower Chalk is 132 feet.* It is characterized not only by its distinct fossil fauna, but also lithologically by the almost complete absence of flint, by it less indurated texture and less massive bedding as compared with the overlying Middle Chalk or Chalk-with-Flints, and by the greater abundance of shaly partings in it. The effect of this difference upon the profile of the cliff is well brought out in the plates. The Lower Chalk forms the base of the precipice for the first two miles eastward from Speeton, and here the erosion proceeds with comparative rapidity, as is shown by the prevalence of long slopes of fallen material which the sea is constantly removing, and by the presence at low water of a broad rocky foreshore, marking the extent of the work done by the sea since it has stood at its present level. These features may be studied in Plate 2.

The most distant point visible in the view, midway between Buckton and Bempton, shows where the top of the Lower Chalk is brought down to high water mark by the southerly dip of the strata. Beyond this the cliffs are composed from base to crest of the hard thick-bedded Chalk-with-Flints, and form great unbroken walls of rock, as illustrated by the distant cliffs in No. 3. The low water scar is also here reduced to the narrowest possible dimensions or is entirely absent.†

There is a huge slip of the cliff about midway in the Speeton range (where in No. 2 the dark shadowy slope is seen to extend down to the shore), known as Crowe's Shoot. At this place a great slice of

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* A detailed description of this part of the Section will be found in Mr. W. Hill's paper "On the Lower Beds of the Upper Cretaceous Series in Lincolnshire and Yorkshire." Quart. Journ. Geol. Soc., xliv., p. 320.

† It must be noted that No. 2 has been taken when the tide was more than half-way out, and No. 3 at near high tide, but the above statement holds good as regards the Bempton Cliffs whatever the state of the tide. The shadow of the cliffs upon the water, in No. 3, might at first glance be mistaken for a tidal platform.

Chalk 150 yards long has moved forward and downward for 50 or 60 feet, but has then been arrested and has remained without further change for over a generation. Under favourable circumstances a good climber may generally here ascend or descend the cliff, which is 425 feet high, without much risk ; but between this place and Chatterthrow, near Thornwick, a distance of four miles, there is as a rule absolutely no possibility of descending to the shore except by means of ropes. It chanced however that during the winter of 1895-6 there was a very heavy fall of the cliff at Old Rollup, opposite Bempton, and last Easter when I was over the ground with two friends, we found it possible to descend at that place quite easily to the shore, a fact worth recording, as it may be very many years before such conditions recur.

The drifts, from 30 to 50 feet thick, which cap the high cliff known as Raincliff, in the middle distance of No. 2, consist mainly of rudely stratified clayey gravel and sand with some boulder clay, the stones both in the gravel and in the clay being almost entirely of distant origin. Their position on the crest of the escarpment is remarkable. The ground slopes inland from near the edge of the cliff to form the Bempton Valley, and the main mass of the drift runs in a rude chain of mounds on the top of the slope without descending into the valley (see map). This arrangement seems to prove that, in spite of their semi-stratified character, these drifts cannot have been deposited during a period of submergence, but that they have been accumulated as a fringing moraine at the margin of the great ice-sheet which once filled up the bed of the North Sea to a level slightly higher than the cliffs at Speeton. Towards Flamborough where the cliffs sink lower these moundy drifts pass inland across the headland, producing effects to which attention will be called in the other views of the series.*

3. Scale Nab and Bempton Cliffs.

This view, from the opposite direction to the last, shows the continuation of the cliff-range across the parish of Bempton. It is taken from the top of the cliff near Wandale Nab, looking west-north-west. The height of the nearer cliff is 290 feet, and that of the farther, 300 to 325 feet. The out-standing perforated buttress facing the observer bears the name of Scale Nab on the Ordnance Map, but is more usually known as The Staple, and the little bay in front of it as Staple Nook. The whole of the cliff seen in this view is composed of the flint-bearing Middle Chalk, with an attenuated capping of drift. The coast on the northern side of Filey Bay and the high ground behind it, made up of Jurassic rocks, is dimly seen on the distant horizon.

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* The Drifts of Flamborough Head have been described by the author in Quart. Journ. Geol. Soc , vol. xlvii., p. 384, (1891) where also the bibliography of the subject is recorded.

This picture brings out admirably the striking contrast there is between the tame featureless chalk plateau and the boldness of the great vertical walls which bound it. In the sharp truncation of the plateau by the cliffs we realise how much land the sea must have torn away in spite of the unyielding nature of the rock. At this place the edge of the Bempton Valley lies a little way inland. The moundy drifts which hug the top of the ridge can just be seen at the left hand margin of the picture.

The chief geological interest of the view, however, centres in the magnificent contortions visible in the nearer cliff, though these are not very clearly seen in a picture on so small a scale. These contortions were well illustrated by three large autotype photographs issued by our Society in 1885, accompanied by a short descriptive account from the pen of our late Secretary, Mr. J. W. Davis.*

The disturbance sets in suddenly a little to the left of the section seen in No. 3, and dies out as suddenly on the farther side of The Staple. For a space of about 200 yards the whole height of the cliff shows the strata plunging steeply this way and that in a series of sharp folds. Both eastward and westward of this place the beds lie quite regularly with a very gentle dip southward. It is not improbable that these contortions are accompanied by a fault, but there is no very satisfactory proof of this,† and the amount of throw cannot be great. In various parts of the headland the slickensides on the joint-faces exhibit indications of slight horizontal movement, and sometimes the same feature may be observed along the marly bedding planes. In one instance, under Buckton, about 1½ miles to the westward of the present section, the uppermost beds of the Lower Chalk have been locally crushed by the sliding forward of the massive overlying beds of the Middle Chalk, and an appearance of slight unconformability has thus been produced.* Contortions are known to exist in the chalk in many places in the interior, and a careful study of these in connection with those of the cliff-line would probably reveal the presence of definite zones of pressure and movement traversing the whole district.

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* Proc. Yorksh. Geol. and Polytech. Soc., vol. ix., p. 43.

† See discussion on this point in "Notes on the White Chalk." Proc. Yorksh. Geol. and Polytech. Soc., vol. xiii., p. 73.

Staple Nook evidently owes its existence to the slightly less resistant power of these contorted beds. A fine spring of fresh water rises along them and flows from the base of the cliff at low tide. Old Rollup, mentioned above, is the recess next beyond The Staple.

These cliffs are, in the early summer months, the breeding place for vast multitudes of sea birds, chiefly guillemots ("scoots"), razor-bills ("auks"), kittiwakes and puffins, and the gathering of the eggs for sale as food has been practiced for generations by the inhabitants of the neighbouring villages, whose skill in the use of the climbing ropes is quite extraordinary.

4. Little and Great Thornwick Cliffs.

In this view our standpoint is the little headland on the western side of the recess known as Chatterthrow, nearly two miles to the eastward of Staple Nook. We look eastward across the succession of ridges and inlets which are shown from the opposite side in the next Plate and will shortly be more fully discussed.

The perforated ridge between Chatterthrow and Little Thornwick is in the foreground,† that between the two Thornwicks in the middle distance, with the cavernous eastern side of Great Thornwick, shown in a nearer view on Plate 6, in the background.

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* See fig. 2, p. 10, in Mem. Geol. Survey: "Country around Driffield" (Sheet 94, N.W.), and notes on section, by the writer, in "La Géologie de l'Est du Yorkshire," in Compte Rendu du Congrès Géologique Internationale, Londres, 1888., p. 154.

† A large photograph of this headland was issued by the Society with their annual volume for 1882, vol. viii. I was requested to prepare the description (vol. viii., p. 103) which accompanies it, but, by a misunderstanding, while I described a view of the eastern side of Great Thornwick (shown in pl. 6 of the present series) which had been taken as an alternative, the photograph actually issued was afterwards substituted, so that in some points the description was quite inapplicable.

The stratification of the chalk is beautifully brought out in this picture, as also the tendency of the rock to become broken and rubbly immediately beneath the drifts. Its hardness and solidity, as compared with the more usual type of English Chalk, is well indicated by the deeply indented profile of the cliffs. It may be advisable to mention that the dark tint of the lower part of the cliffs, so apparent in this and other pictures of the series, is merely superficial staining from organic agencies, marking the limit of the waves.

5. Thornwick and Bempton Cliffs.

This, like the third view, looks westward. The ridges seen in the last plate fill the middle of the picture, the point of view being on the eastern side of Great Thornwick. In the middle distance the Bempton Cliffs are again seen, their straight massive outline scarcely suggesting stratified material. Staple Nook lies in the recess between the most distant and the next nearer headlands. The Middle or Flinty Chalk is alone in sight. In the corner of the little bay in the foreground it is rather rich in gigantic *Inocerami.* The change which takes place in the contour of the coast in the nearer cliffs, from a simple or only slightly wavering line to any intricate tracery of deep inlets and narrow headlands, showing on the map like the suture-lines on an ammonite, cannot fail to strike the observer. The characteristic irregularity is retained from this place to the most easterly point of the headland, two miles distant. As there is no corresponding change in the hardness of the rock we must seek some other cause to account for it. This cause is, I think, revealed very clearly in the plates.

It has already been mentioned that the Bempton Valley lies a little way inland from the edge of the great cliffs, from Speeton eastward. The northern cliff-line of the headland cuts the land slightly obliquely to the course of this ancient valley, so that eastward from Bempton the northern side of the hollow is more and more deeply carved until near Thornwick this side of the valley has almost disappeared. The hollow is of preglacial date, and its lower portion is so choked with drift as to be nearly obliterated as a surface-feature, so that its true course from Bempton eastward is somewhat problematic. But the cliff-sections from Thornwick eastward clearly indicate the existence of the buried valley, invariably showing the solid rock to be higher above the sea on the headlands than in the recesses. In the deeper bays the surface of the chalk is frequently only slightly above high-water mark, the remainder of the cliff being composed of clayey or gravelly drift. One result of this is that when the sea has once managed to break through some weak place in the outer part of the valley-wall, the rock being lower and more shattered by ancient weathering within, gives way at an accelerated pace until the gash across the drift-filled hollow becomes deep enough to afford some shelter to the inner walls of the recess. The succession of ridge and inlet, so well shown in plates 4 and 5 illustrates the structure. In the second of these plates Great Thornwick lies just below us, divided by a narrow barrier from Little Thornwick, beyond which, across a slightly broader ridge, is Chatterthrow. The dividing ridges have a heavy capping of drift, consisting chiefly of tough boulder clay, though with many interbedded patches of gravel and silt or sand. Where narrow, they weather down from both sides into picturesque arêtes. Fragments of marine shells occur rather plentifully in this drift, but seem to have been introduced with the other pebbles, and are not a trustworthy indication that the deposits are marine.*

There is a feature in the nearer ridge which affords an excellent small-scale illustration of what often occurs on a large scale in mountainous regions. It is the existence of a short dry valley or col crossing the ridge, to be observed near the left-hand margin of the picture. This col is the abandoned channel of a little stream which trickled down into this corner of Great Thornwick, until intercepted by the wearing back of Little Thornwick, where it now discharges itself to the sea. Marine erosion has in this instance done what in hilly districts is usually done by another stream, and by tapping the valley has diverted the drainage and left the dry channel.

6. GREAT THORNWICK.

The chief features of this view, showing the eastern side of

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* Further information with regard to these sections may be obtained in Quart. Journ. Geol. Soc., vol. xlvii., p. 403.

Great Thornwick at low water, have already been outlined. It illustrates the formation of caves and fissures by the action of the waves along vertical joints. As I showed in last year's number of our Proceedings, these joints are frequently small faults of a few inches' throw.

In such cases there is usually a slight crushing of the adjacent surfaces, rendering the rock less resistant. Besides the direct scouring action of the waves, it is very certain that they exert a considerable indirect effect in alternately forcing before them air under pressure into the fissures, and then withdrawing it in their rapid fall. In many spots along these tunnelled cliffs one may see in stormy weather the forceful puffing out of steam-like bodies of spray from crevices communicating with the caverns into which the great waves are rolling.

It is no doubt in this way quite as much as by the action of frost that the domes of the caves are sometimes heightened far beyond the direct wave erosion.

7. Western Side of North Sea Landing.

This and the following pictures of the series serve to illustrate the details of the jagged coast between North Sea Landing and the extremity of the headland, and are especially instructive as to the working methods of the agencies of erosion.

This view shows the natural arches, named on the old 6-inch map 'Bacon Flitch Hole,' on the western side of North Sea Landing, the standpoint being on the top of a spur of the adjacent cliff, looking northward. The height of the cliff is about 70 feet. It consists of Chalk-with-Flints, with a capping of Glacial drift. Fossils are rare in this portion of the Flinty Chalk, and very difficult to extract on account of the hardness of the rock. There occurs, however, in the corner of the Landing a little to the southward of this section, a thin seam containing fragments of the stems or arms of a crinoid (probably *Bourgueticrinus*) in abundance. The main archway has evidently been excavated along the joint (or joint-fault) plane which is seen above the crown of the arch on the right-hand side. One can see that in the course of time the crumbling down of the rock along this plane will bring about the destruction of the arch and the severance of the outer mass from the inner cliff. An outstanding stack like those of the next three plates will thus be formed.

8. THE KING AND QUEEN ROCKS.

The King and Queen Rocks shown in this plate are the largest and best known of the isolated rock-pinnacles of the headland. They stand in a little recess of the coast under Breil Point, seven hundred yards eastward from North Sea Landing. The Queen, the nearer of the two, is about sixty yards from the shore at high tide, and the King stands fifty yards farther out, at the extreme edge of the low-water scars.* The point of view for this picture is at the top of the cliff in the recess, 150 feet above sea level, looking north-eastward. The precipice to the right forms part of Breil Point. The whole section is composed of the Chalk-with-Flints, but is not far from the top of that division where the bedding is less massive than at lower horizons.

9. SELWICKS.

Selwicks, lying immediately to the north of the most easterly point of the headland, owes its existence to a fault,† accompanied by a contortion of the strata, which at this place intersects the coast line. The fault runs east and west and has a downthrow to the north of about 70 or 80 feet. We have in this vicinity the junction of the Chalk-with-Flints or Middle Chalk with the overlying flintless Upper Chalk, and the effect of the fault is to bring down the Upper Chalk into the cliff-section on the northern side of Selwicks against the harder Chalk-with-Flints which occupies the whole of the cliff on the opposite side of the Bay.

No. 9 is a view of this bay at low-water, the standpoint being on the southern side, looking northward. The line of faulting crosses the scar in the foreground, approximately along the water-channel seen on the right. The nearer cliff, so grandly carved and tunnelled by the waves, and the pinnacle standing like a sentinel in front of it, are composed of the lowermost layers of the Upper Chalk, with the top of the Chalk-with-Flints just reappearing on the shore to the eastward of the inlet on the left. In the farther headland, about

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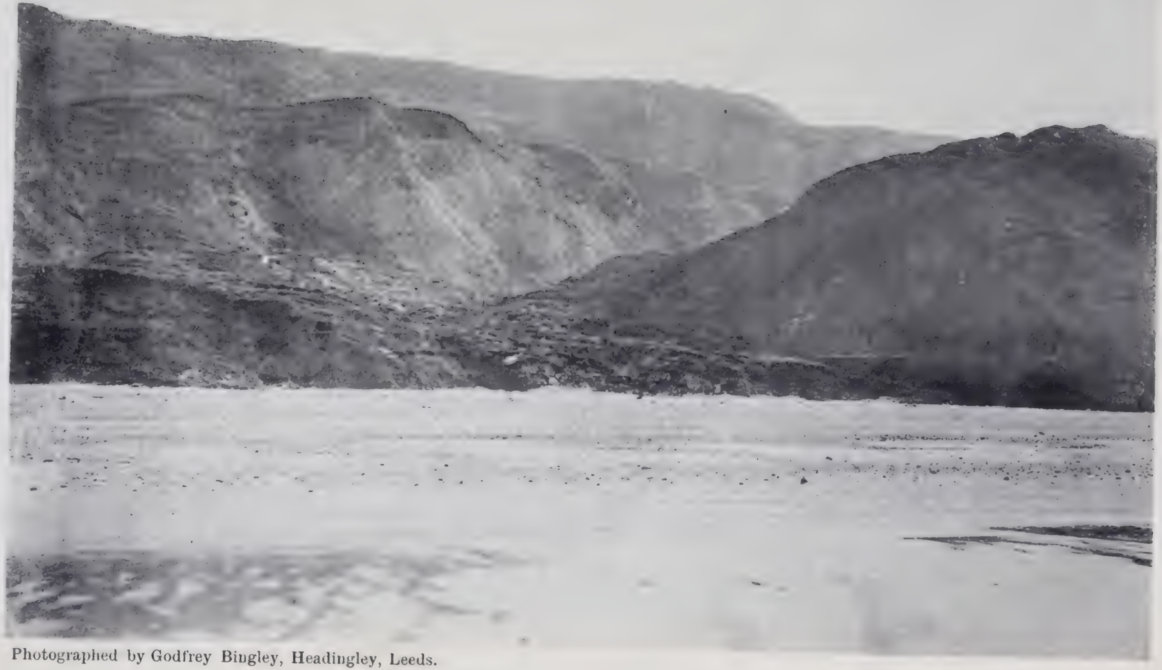
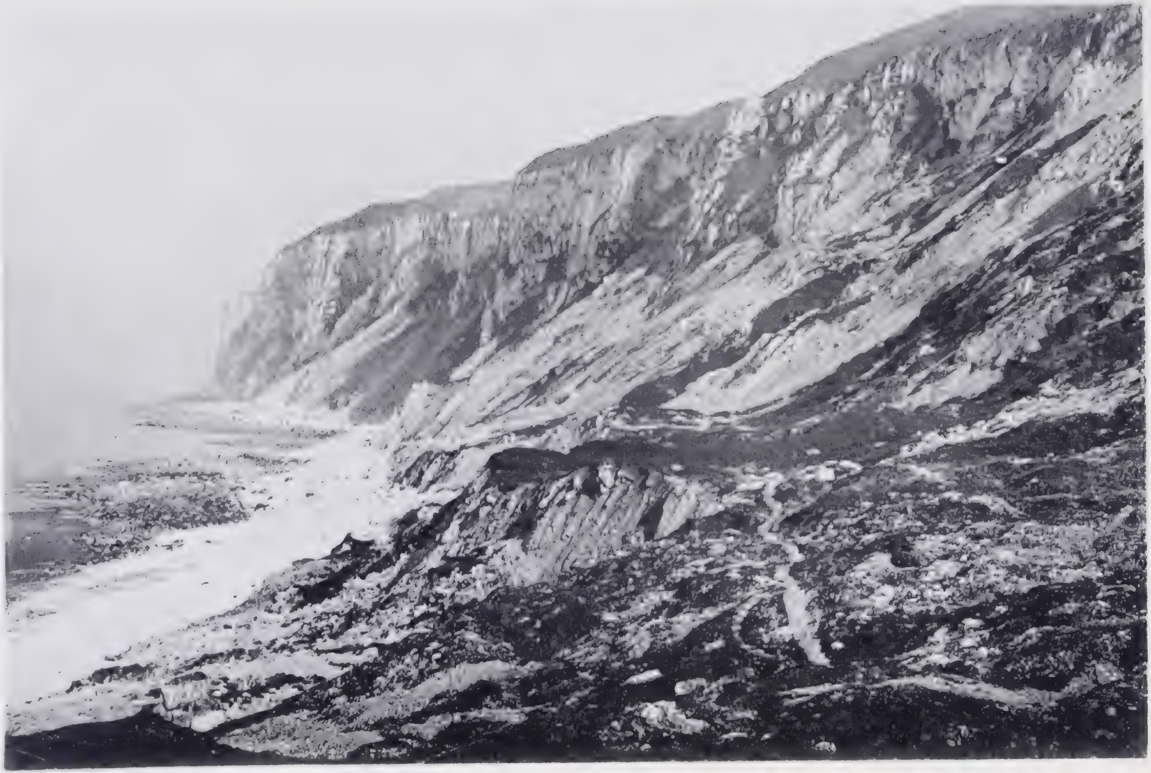
* As named on the old Ordnance map. Some confusion exists locally as to which of these rocks is King and which Queen, though collectively their names are well-established. The same remark applies to "Adam and Eve" in Selwicks Bay (see p. 183).

† First described in my paper in Proc. Yorksh. Geol. and Polyt. Soc., vol. vii (1880), p. 242.



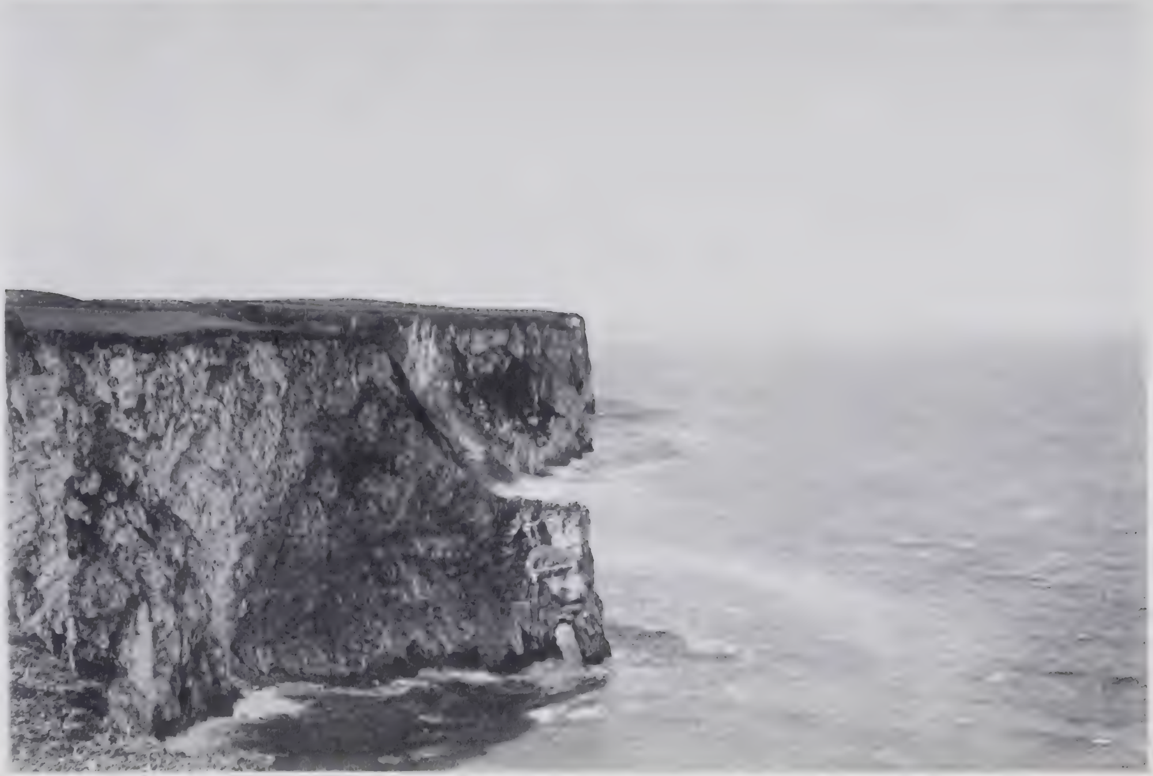
Photographed by Godfrey Bingley, Headingley, Leeds.

1. Speeton Gap (looking Southward.



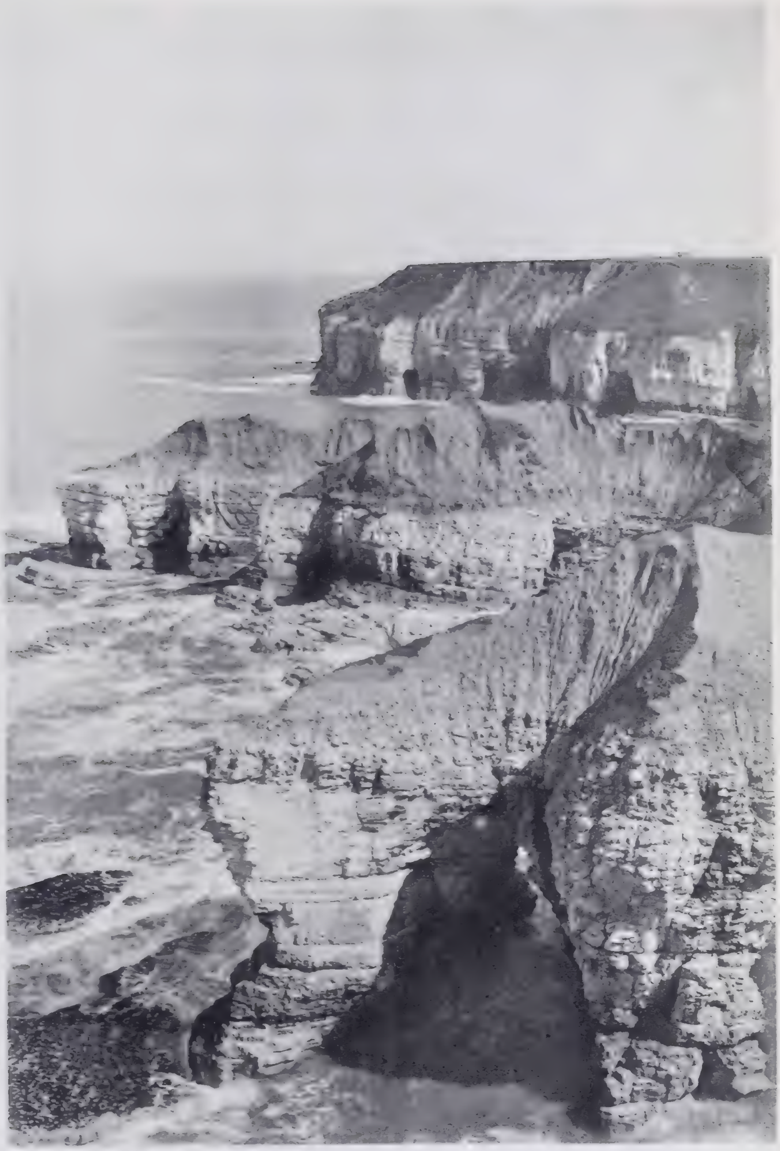
Photographed by Godfrey Bingley, Headingley, Leeds.

2. Speeton Cliffs (looking Eastward).



Photographed by Godfrey Bingley, Headingley, Leeds.

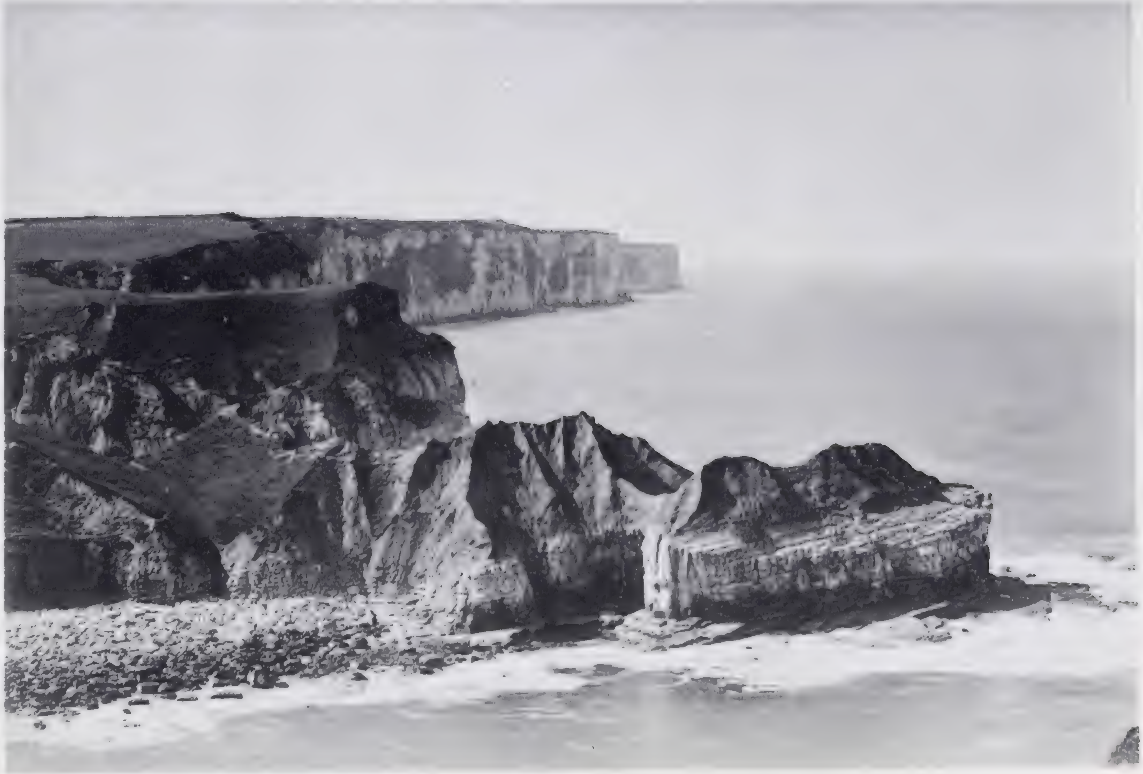
3. Scale Nab and Bempton Cliffs (looking Westward).



Photographed by Godfrey Bingley, Headingley, Leeds.

4. Little and Great Thornwick (looking Eastward).

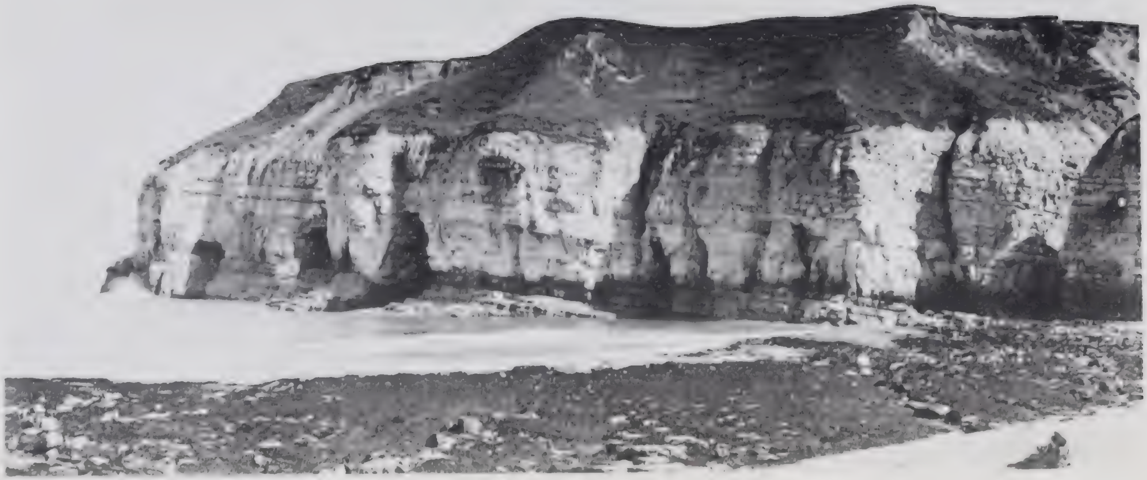
Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII. Plate XXV.



Photographed by Godfrey Bingley, Headingley, Leeds.

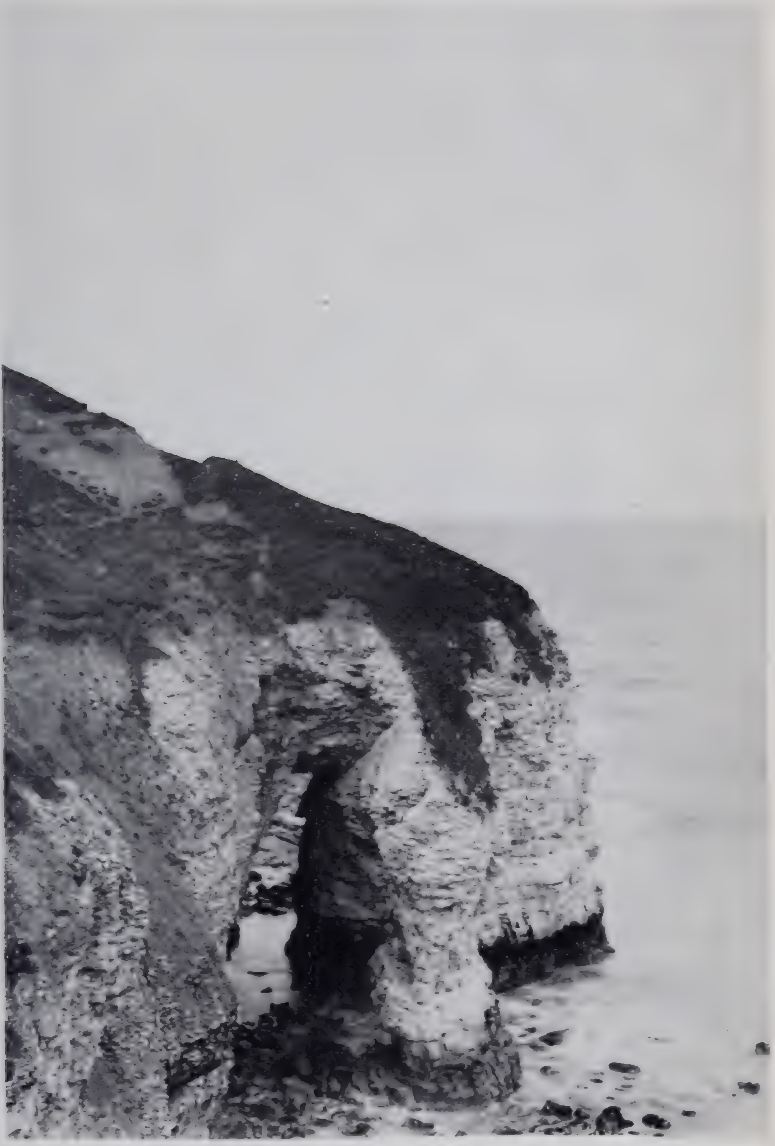
5. THORNWICK; AND BEMPTON CLIFFS (looking Westward).

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII. Plate XXVI.



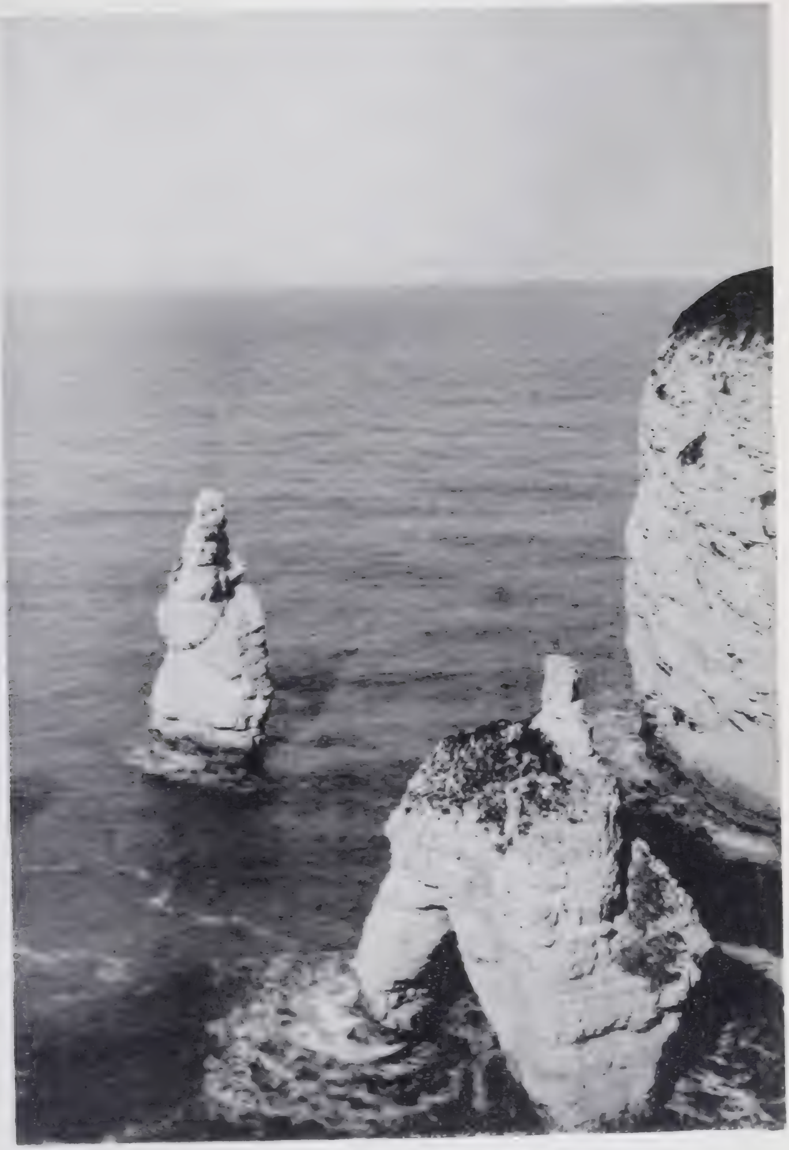
Photographed by Godfrey Bingley, Headingley, Leeds.

6. Great Thornwick (looking Eastward).



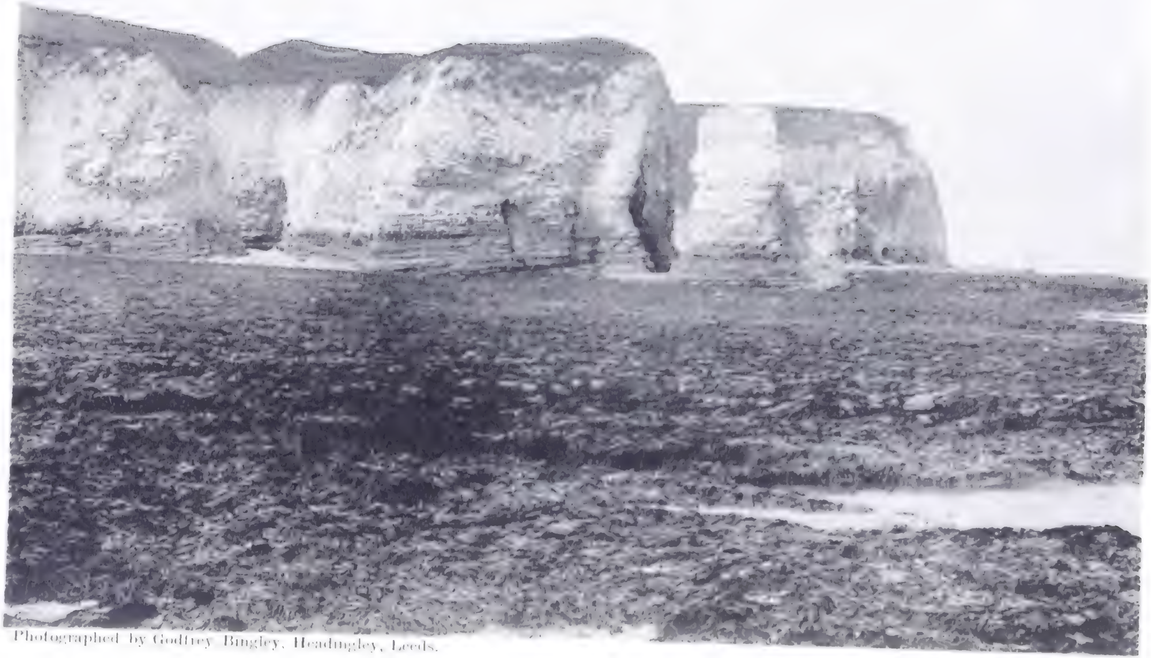
Photographed by Godfrey Bingley, Headingley, Leeds.

7. Western Side of North Sea Landing, Flamborough (looking Northward).



Photographed by Godfrey Bingley, Headingley, Leeds.

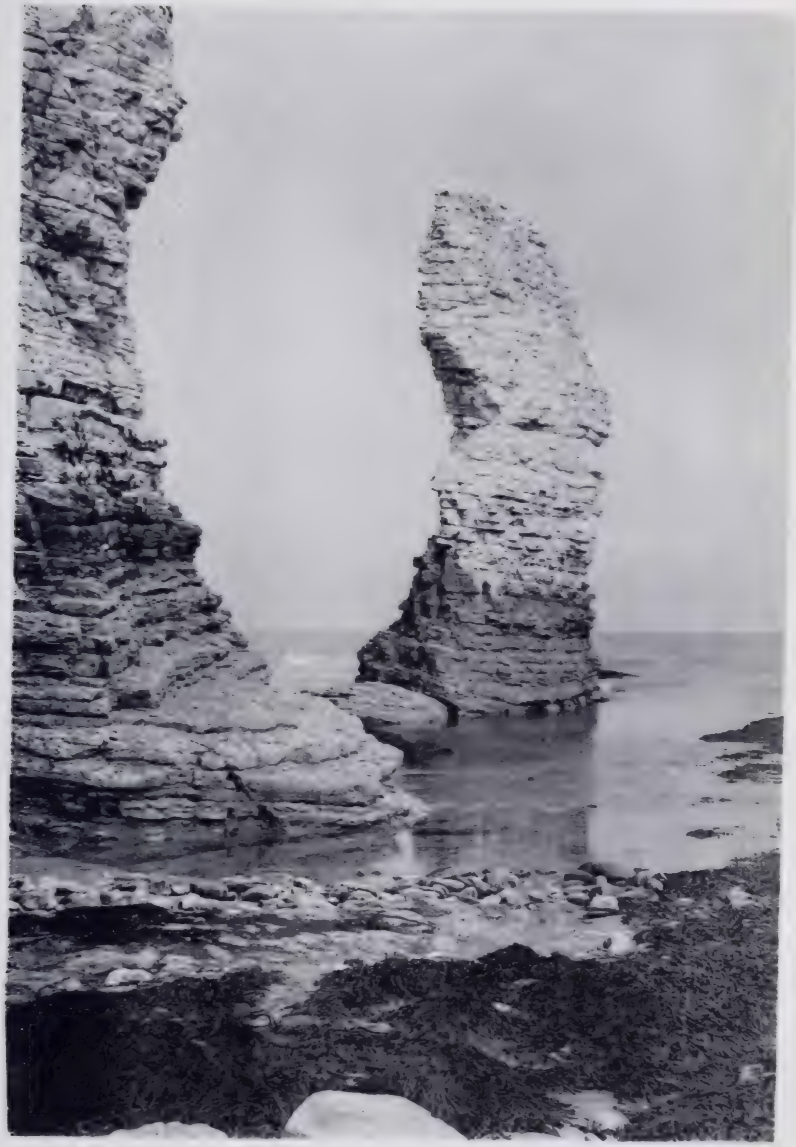
8. THE KING AND QUEEN, FLAMBOROUGH HEAD
(looking North-Eastward).



Photographed by Godfrey Bingley, Headingley, Leeds.

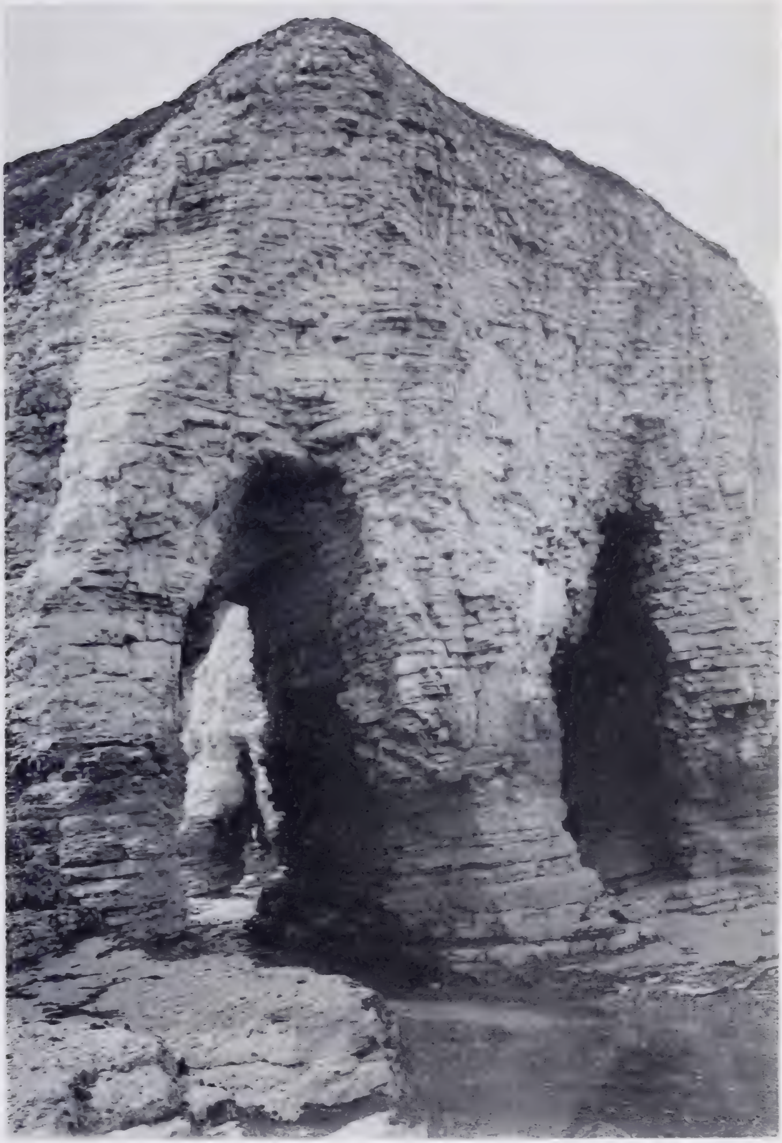
9. Selwicks, Flamborough Head (looking Northward at low water).

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII. Plate XXX.



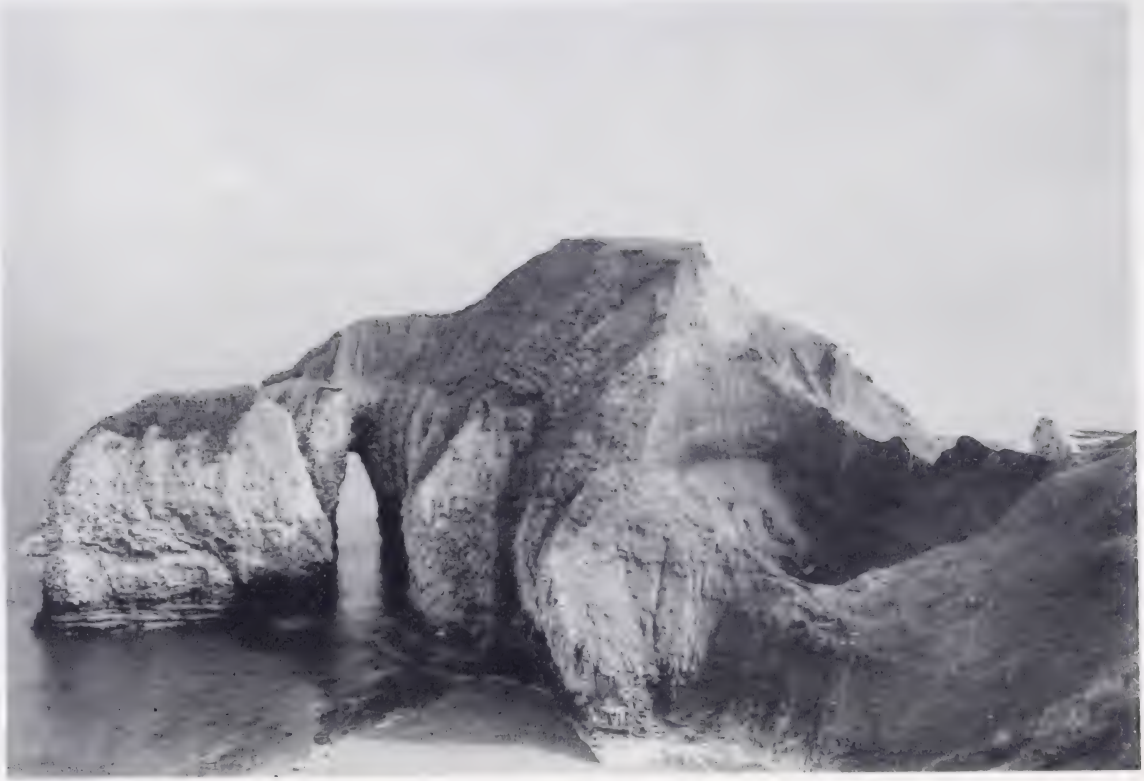
Photographed by Godfrey Bingley, Headingley, Leeds.

10. North Side of Selwicks, Flamborough Head (looking Northward).



Photographed by Godfrey Bingley, Headingley, Leeds.

11. AT KENDLE SCAR, SELWICKS (looking South-Eastward).

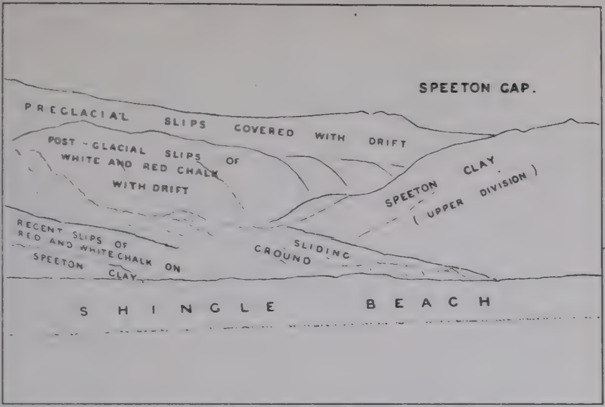


Photographed by Godfrey Bingley, Headingley, Leeds.

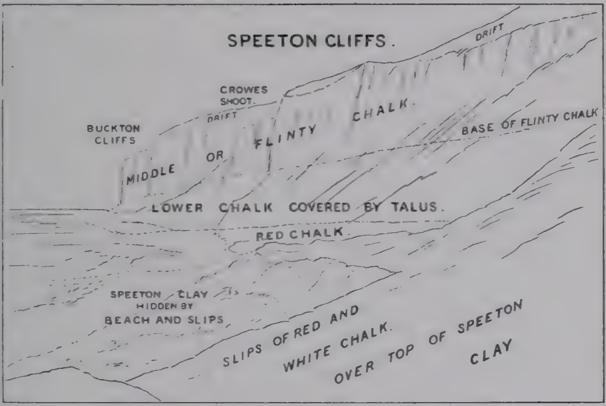
12. High Stacks, Flamborough Head (looking South-Eastward).

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII. Plate XXXIII.

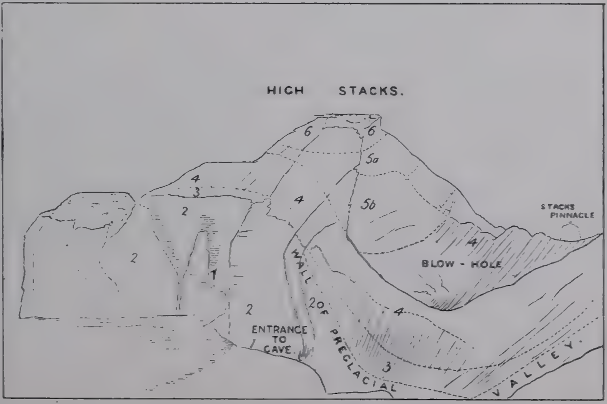
KEY - PLATE.


SPEETON GAP.
PREGLACIAL SLIPS COVERED WITH DRIFT
POST-GLACIAL SLIPS OF WHITE AND RED CHALK WITH DRIFT
SPEETON CLAY (UPPER DIVISION)
RECENT SLIPS OF RED AND WHITE CHALK ON SPEETON CLAY
SLIDING GROUND
SHINGLE BEACH

(A) KEY TO PL. I. SPEETON GAP.


SPEETON CLIFFS.
DRIFT
CROWES SHOOT.
DRIFT
BUCKTON CLIFFS
MIDDLE OR FLINTY CHALK.
BASE OF FLINTY CHALK
LOWER CHALK COVERED BY TALUS.
RED CHALK.
SPEETON CLAY HIDDEN BY BEACH AND SLIPS
SLIPS OF RED AND WHITE CHALK. OVER TOP OF SPEETON CLAY

(B) KEY TO PL. II. SPEETON CLIFFS.



EXPLANATION.

6. Upper boulder clay.
5a. Chalky Gravel, with lenticle of boulder clay at base.
5b. Chalkless Gravel.
4. Lower Boulder Clay.
3. Chalk-rubble at base of Drifts
2. Upper Chalk (flintless)
1. Chalk with flints.

(C) KEY TO PL. XII. HIGH STACKS.

140 feet high, which shuts in the view northward, the steady rise of the strata again brings up the Chalk-with-Flints to form the lower half of the cliff. It will be seen that there is in this neighbourhood a heavy capping of drift, and this presents many points of interest. It is composed in places almost entirely of re-arranged Speeton Clay pushed up by the ice in its southward progress, so that one may here collect characteristic Lower Cretaceous fossils above the Chalk. Fragments of Arctic marine shells are also rather abundant in certain spots, more especially on the tumbled slope in the middle of the bay, to the left of the picture. Beneath the drift the superficial layers of the Chalk are frequently severely contorted by glacial action, such contortions fading out gradually downward. This feature is scarcely perceptible in the photograph, but it may be studied to advantage in the recess between the nearer and the distant cliff, and better still on the southern side of Selwicks.*

10. North Side of Selwicks.

In this plate we have a nearer view of the graceful pinnacle and the cliff adjacent to it which are seen in the last picture. The photograph is so beautifully clear that I think one may detect the flints in the Chalk at the base of the cliff, and may thereby fix the line of junction of the Middle with the Upper Chalk. A very similar pinnacle guards the opposite side of the bay, and the two are known together as Adam and Eve; but whether this be Eve or Adam I cannot tell.

11. At Kindle Scar, Selwicks.

This, again, is a closer illustration of the detail of the cliff seen in Plate 9. The point of view is at the base of the cliff below high-water mark, a little to the northward of the pinnacle, looking inward through the arches which perforate the ridge, into the deep recess known as Molk Hole, seen to the left in Plate 9. This portion of the coast bears the name of Kindle Scar on the 6-inch Ordnance Map.

12. High Stacks, the extremity of Flamborough Head.

The most easterly point on Flamborough Head, known as High Stacks, is shown in this photograph. The standpoint for the view is on the slope of the cliff, looking south-eastward. The Chalk forming the prominent cliff comprises the lowermost beds of the Flintless Upper Chalk, with the top layers of the Chalk-with-Flints seen only below high-water mark. Above the Chalk there is a considerable thickness of glacial drift, and it is in the relation of this to the solid rocks that the chief interest of the section lies. A ravine existed in this locality in pre-glacial times which has been filled in and obliterated by drift-deposits, and this valley with its infilling is intersected by the cliff (see key-plate fig. C). A little cave which the sea has excavated in the Chalk near the eastern margin of this valley has penetrated the rock and reached the less coherent drift material lying within, and has rapidly abstracted it through the orifice until at length the whole roof of the inner portion of the cave has fallen in. producing the crater-like hollow seen in the picture. When I first knew this place the cave was smaller than it is now, and whenever the sea was rough the waves at high-tide choked up the passage to the crater, causing the imprisoned air frequently to eject a vertical column of spray to a considerable height, like a great whale blowing. Of recent years, with the enlargement of the cavern, this phenomenon has been of less frequent occurrence. In the old 6-inch Ordnance Map a continuous ridge is shown over the site of the blow-hole, so that it would appear that the roof of cave has fallen in within the last 45 years.

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* See "Drifts of Flamborough Head," *op. cit.*, p. 402.

Another larger hole of similar character, known as Pigeon Hole, occurs in the same valley-course, 400 yards to the northward of High Stacks, near the Lighthouse.

The drift deposits filling the depression are of varied character* (see key-plate, fig. C). Between an Upper and a Lower Boulder-clay forming the top and bottom of the series occur stratified gravels, with a thin band of interbedded Boulder-clay. A marked peculiarity of these gravels is that while the upper portion is largely made up of chalk-fragments the lower part contains a medley of distant rocks, but scarcely a trace of Chalk ; and the line of division between the two gravels is quite sharp and distinct. There are several other instances of the same peculiarity, in the drift sections on the southern side of the headland. I have suggested* that the explanation is that the Chalkless gravels were washed from the margin of the glacier lying to the eastward, while the Chalky gravels were swept down the valley from the bare Chalk Wolds to the westward, and the alternations were produced where the floods from opposite sides poured into the same hollow.

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* For full details see J. R. Dakyns. Proc. Yorksh. Geol. and Polyt. Soc., vol. vii. (1879), p. 126 and p. 250. Also Lamplugh "Drifts of Flamborough Head," op. cit., p. 401.

PART II. NOTES ON THE AGE AND PHYSICAL HISTORY OF FLAMBOROUGH HEAD.

The foregoing descriptions will serve to elucidate the stratigraphy of the headland, and in conclusion a brief retrospect of its geological history may be permissible.

Throughout the Upper Cretaceous period this region, in common with the whole of eastern and southern England and the greater part of Central Europe, lay submerged beneath the sea. The probable depth of this sea is still a matter of debate. By some geologists it is held that the Chalk was formed at great depths like the Globigerina-ooze of the Atlantic Ocean, while other students of the subject consider that the deposit may have accumulated in comparatively shallow waters. As to the probable westerly bounds of this Upper Cretaceous Sea there are also, from the vagueness of the evidence, differences of opinion. The whole of Western England may have been covered and the chalky sediments of the Eastern Counties been conterminous with those of Northern Ireland. But it is more probable that the Pennine axis and the hills of Wales, with other elevated tracts of the older rocks, stood above the water, forming land-areas of limited extent.

There is a very pronounced thinning of all the marine Jurassic and Lower Cretaceous strata of the north of England in a westerly direction, and also a change of character indicating the proximity of land. The same features are repeated in the lower part of the Upper Cretaceous rocks, and possibly throughout the formation.† We may therefore assume that the deposit of Chalk attained in England its maximum thickness near our present eastern coast-line, and that its westerly extension thinned off towards a shore-line where deposits of detrital matter like those of various parts of the European Continent marked the original limits of the Upper Cretaceous Sea.

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* Drifts of Flamborough Head," op. cit., p. 421.

† See W. Hill. Quart. Journ. Geol. Soc., vol. xliv., p. 320 ; also Lamplugh. Proc. Yorksh. Geol. and Polyt. Soc., vol. xiii., p. 76.

However this may be, one thing is certain, that the Chalk has originally extended much farther to the northward and westward in Yorkshire than it does nowadays, and that over wide areas it has been entirely removed by denudation. There are in the North of England no "solid" beds above the Upper Chalk, the whole of the Tertiary sediments being unrepresented. We have, therefore, no indications within the area to guide us in framing an idea of the progress of events between the close of the Cretaceous Period and the beginning of Glacial conditions. By looking farther afield, however, to the South of England and to the opposite shores of the North Sea, we may gain sufficient information to speculate upon the probable sequence of conditions during this great interval.

While the uppermost layers of the Chalk were in the process of deposition a slow elevating movement seems to have set in, which either before or in very early Eocene times quietly brought up the area above sea-level. The erosion of the Cretaceous strata then commenced, and went on with increasing rapidity as the land gained gradually in elevation. Minor fluctuations of level occurred during the later stages of the Eocene and the earlier Oligocene, but these were not of sufficient importance to alter the general character of the period so far as this area is concerned, and the wasting of the land continued. The culmination of these geocratic movements occurred in Miocene times, when the district participated to some extent in those vast disturbances which affected the whole of the Eurasian continent.

The earth-pressure in some regions built up high mountain-chains, and in others caused outburst of volcanic activity of extreme magnitude. In the south of England it threw the Secondary rocks into broad folds, and locally into sharp contortions ; and such disdisturbances of the Chalk in the north of England as are revealed in the Staple Nook and other sections, may with every probability be referred to the same series of forces. From the character of the contortions we gather that they must have been formed under a great weight of superincumbent rock. The strata in which we now see them were originally covered by at least another 900 to 1000 feet of Chalk,* and it is very probable that the greater part of this covering was in existence when the folding occurred. As to the upward extent of the contortions or the mode in which the the forces were manifested in the higher beds of the series we have of course now no means of judging. As a further mark of the enormous quantity of rock which has been denuded from the Wolds since the time of these contortions, it will be well noted that, as the photograph shows, there is no feature at the surface to indicate the existence of the contorted zone, so that had it not been for the accident of a convenient cliff-section we should not have discovered it here. So far as we can judge, this denudation has been effected by subaërial agencies, and not by the planing action of the sea, as there are no adequate grounds for supposing that the Yorkshire Wolds have been submerged since Miocene times.†

By these denuding agencies not only has the Chalk plateau been everywhere lowered, but its edges have also been cut away, and so undermined by the removal of portions of the softer underlying clays and shales, that a steep escarpment has been shaped out along its inland termination ; and by the prolonged recession of this escarpment the Chalk has been diminished to its present bounds. Yet this denudation has been accomplished within time limits, which are, geologically speaking, comparatively short.

Throughout early Pliocene times the district was probably always considerably elevated, and during this period the broader of our present Wold valleys were partially excavated. The general tendency of the oscillations of level was now however to depress the land, and in the later stages of the Pliocene, marine encroachment began to affect the area, and a coast-line was carved out across the Upper Cretaceous rocks somewhat to the eastward of that of the present day. In this coast-line the Headland of Flamborough gradually emerged as a prominent feature.

With some minor changes of level, these conditions probably persisted until the beginning of the Glacial Period. Of this stage direct evidence is forthcoming in the sections. There exists at the foot of the Chalk escarpment at Speeton, beneath all the glacial drifts, an estuarine shell-bed, some 80 feet above the shore, yielding a limited fauna of shells all referable to species still extant. On the opposite or southern side of the headland the Chalk-section terminates abruptly near the village of Sewerby in a very well-preserved ancient sea-cliff, with a shore-deposit at its foot nearly at the present sea-level. This ancient cliff and shore is buried beneath all the drifts. By means of excavations into the old shingle undertaken jointly by this Society and the British Association, we have obtained the remains of extinct species of elephant, rhinoceros, hippopotamus, etc , along with a few land and sea-shore shells of existing species.* Though there is some difference of level between these two deposits they appear to belong approximately to the same period.† During their accumulation the headland must have been a much more prominent feature of the coast-line even than it is to-day, for the sea then covered, on its southern side, the whole of Holderness up to the foot of the Wolds, and on its northern flank ran far inland along the Vale of Pickering, forming a long estuarine inlet which received the waters of the Derwent and its tributaries. Then, too, the extremity of the headland would reach out further eastward by so much as has since been lost through erosion, so that the Flamborough Head of Preglacial times must indeed have been a noble promontory !

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* See "Notes on the Chalk of Yorkshire." *Op. cit.*

† Some interesting data and speculations regarding the subaërial wasting of the Chalk of the district will be found in the papers by Mr. J. R. Mortimer and by Rev. E. M. Cole, referred to in the previous part of these Notes.

Throughout Pliocene times there had been an increasing refrigeration of the climate, and at the period of these beaches ice-floes bearing erratic pebbles occasionally drove ashore in the bays. No doubt the accumulation of glacier-ice had by this time already attained considerable dimensions among the higher hill-ranges of Northern Britain and Scandinavia, and in both regions had crept down to tide-water, and had begun to displace the sea in the shallows around the coasts. Although it was not until later that any part of these glaciers reached East Yorkshire, the climatal conditions were nevertheless very favourable for rapid denudation in the area, and streams were everywhere busy in carving out the intricate valley systems of the Wolds, among which we may reckon the Preglacial hollows revealed in the cliff-sections of Flamborough Head. Whatever rain falls on the Wolds now-a-days sinks at once through the pervious soil into the interstices of the porous Chalk, so that no running water exists in any of the valleys, except in a few instances where the valley bottom lies temporarily or permanently below the saturation-level in the Chalk. But during the erosion of these valleys the conditions were such as to produce an abundant flow at the surface. Not only must there have been a much heavier rainfall and snowfall (a "Pluvial Period," in fact), but also, probably, a permanently frozen subsoil which formed an impervious cover to the porous Chalk, and thus prevented the absorption of the surface waters.* Such conditions appear to have been more or less continuous in the Wold district throughout the Glacial Period, and to have persisted into Post-Glacial times.

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* Report on the Buried Cliff at Sewerby, by G. W. Lamplugh. Proc. Yorksh. Geol. and Polyt. Soc. (1887), vol. ix., p. 381 (plate 21). Also Rep. British Assoc. Bath (1888), p. 328, and (1890), p. 799.

† See "Drifts of Flamborough Head," op. cit.

There is clear evidence of an elevation of the land shortly before the deposition of the Glacial deposits. This may have occurred either before or after the accumulation of the Sewerby and Speeton Infra-Glacial marine beds, the data in hand being insufficient to determine the point, though the latter supposition seems the more probable. One proof of this elevation is that most of the valleys draining eastward to the present coast are excavated considerably below the present sea-level. At Scarborough, for example, there is a drift-filled valley the bottom of which is 100 feet below mean-tide,† and at Bridlington the valley of the Gypsey Race goes considerably below sea-level. In a minor degree this is true also of certain of the buried hollows which trench the Chalk of Flamborough Head. This elevation probably continued throughout the earlier stages of the Glacial Period. It favoured the accumulation of that great ice-sheet which afterwards gradually filled up the basin of the North Sea until an icy plateau linked our islands to Scandinavia and Germany.

The flank of this ice-sheet rose high against the coast-line, but the mass seems never to have been sufficiently deep to over-ride entirely the Chalk escarpment at Speeton, perhaps partly because of the abruptness of the cliffs and partly because the main current of the ice-flow was to some extent deflected by the Oolitic hills north of Scarborough. The greater part of the Eastern Moorlands and of the Yorkshire Wolds probably remained as low tracts of land just rising above the margin of the ice which in places sloped rather steeply towards the land, so that its morainic border was sometimes pushed or washed on to the edge of the Chalk plateau, forming irregular mounds, as at Speeton. But on the lower ground near Flamborough the height of the cliff was not sufficient to arrest the ice-flow which therefore passed across the headland into the Bay of Holderness, producing in its passage the varied phenomena already noted. During the long persistence of this Ice-sheet of the North Sea wide oscillations of its margin occurred, so that it sometimes filled up the whole of the Holderness Bay and crept well up the inner slopes of the Wolds, while at other times it receded many miles distant, and its morainic material was washed by floods and deposited in well-stratified sheets over the low ground east of the Wolds.

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* For further discussion of these conditions see "Glacial Sections near Bridlington," part iii., in Proc. Yorksh. Geol. and Polytech. Soc. (1883), vol. viii., p. 251.

† Geol. Survey Mem. "Country south of Scarborough," p. 31.

The steady recession which afterwards set in may, as I have elsewhere suggested,* at first have been due not so much to an actual amelioration of climate as to a diminished snow-fall, consequent upon the greater elevation of the Irish Sea Glacier at this period, by which the greater part of the moisture of the damp Atlantic air currents was intercepted on the western side of England.

Thus a rather dry climate of Arctic severity seems to have marked the later stages of the Glacial Period in the east of England. But subsequently the average temperature rose, the ice-sheets in every part of the country rapidly dwindled, and the rainfall became excessive. At this time the scouring out of the Wold Valleys was again in active progress, and the great spreads of sub-angular chalky gravel which overlie the Drift-series at the mouths of all the Wold Valleys are the records of this period.

The disappearance of the ice-sheet left Flamborough Head almost hidden under a mantle of drift, and the former bays on either side completely choked. The land was probably still elevated above its present level, so that one would have looked eastward from the old headland over a rolling plain continuous with that of Holderness, the hollows of which held numerous pools and lakelets. The climate for some time remained colder than at present, and the fauna included many animals which are now extinct in Britain.

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* Glacialists' Magazine, vol. i., p. 189.

But much detailed work remains to be done throughout the country before the history of the long series of events since Glacial times can be compiled. We know, at any rate, that the land was eventually again depressed, perhaps for a time to slightly below its present level, and that then the sea ate rapidly into the incoherent drift material. The mantle was soon stripped away from the headland, and the waves started work again upon the cliffs of Chalk very nearly at the place where they had left off when interrupted by the ice-age. These ravages of the sea upon the drifts which fill its old bed are still proceeding apace, and if the land should remain at its present level Flamborough Head will some day regain much of its erstwhile prominence, and the bay to the south of it will once more reach to the foot of the Wolds.

SOME YORKSHIRE WELL SECTIONS. BY WM. WHITAKER, B.A., F.R.S., F.G.S., ASSOC. INST. C.E.

(Communicated 29th October, 1896.)

[Words in square brackets inserted by the writer.]

Perhaps the following small collection of well-sections, which are believed to be unpublished, may serve as a nucleus for the gathering together of a greater quantity of like material. The writer will be glad to place any further notes at the disposal of the Society.

Many Yorkshire well-sections have already been described in various Geological Survey Memoirs and elsewhere.

ARMLEY, LEEDS. The Brewery (Mr. J. W. Wright).
Made and communicated by Messrs. ISLER and Co.
Yield, 12 gallons a minute.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Dug Well (the rest bored, 6 inches diameter)		—		98	0
[Coal Measures]	Slate and Coloured Stones	12	0	110	0
	Shale and Rock	22	0	132	0
	Rock	5	6	137	6

BARNSLEY. Old Brewery (Messrs. Clarkson). 1881.
Made and communicated by Messrs. LEGRAND and SUTCLIFF.
No supply.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Filled in Earth [made ground]		4	6	4	6
[Coal Measures]	Yellow Sand and Stone	3	0	7	6
	Sandy Clay	3	0	10	6
	Light [-coloured] and Blue Clay	13	6	24	0
	Grey Stone	3	6	27	6
	Mixed Clay 6 in., and Dark Mixed Bind	8	6	36	0

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
[Coal Measures]	Black Bind	7	6	43	6
	Coal	3	0	46	6
	Fire Clay	14	0	60	6
	Grey Stone	1	6	62	0
	Fire Clay	4	0	66	0
	Grey Stone	4	0	70	0
	Light [-coloured] 2 ft., and very dark Mixed Bind	6	0	76	0
	Black Bind	6	0	82	0
	Black Bind and Stone	3	0	85	0
	Light [-coloured] Bind	3	6	88	6
	Dark and Mixed Bind	2	6	91	0
	Light [-coloured] and Stony Bind	6	6	97	6
	Black Bind, very dry, 1 ft.; and Bind	17	6	115	0
	Mixed	1	0	116	0
	Coal	0	6	116	6
	Bind	29	0	145	6
	Grey Stone	4	0	149	6
	Bind	3	6	153	0

BRADFORD. Messrs. Grandage and Co. 1876.

Bored and communicated by Messrs. LEGRAND and SUTCLIFF.

Water-level, 33 feet down.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
[Coal Measures]	Hard Stone	14	0	14	0
	Black Shale	12	0	26	0
	Blue Rag	5	6	31	6
	Blue Rag, Bind, and Shale	2	6	34	0
	Light [-coloured] Stone and Shale	2	6	36	6
	Hard Stone	21	6	58	0
	Black Shale	2	6	60	6
	Blue Rag	4	6	65	0
	Light [-coloured] Stone	5	6	70	6

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
[Coal Measures]	Black Shale	2	6	73	0
	Dark Hard Stone	3	4	76	4
	Black Shale	10	5	86	9
	Blue Rag	6	6	93	3
	Black Shale	6	8	99	11
	Black Shale Granite [?meaning]	5	9	105	8
	Blue Rag Stone	4	3	109	11
	Hard Black Shale	9	6	119	5
	Hard Stone	2	6	121	11
	Hard Black Shale	19	6	141	5
	Brown Stone	3	0	144	5
	Black Shale	15	0	159	5
	Coal	3	0	162	5
	Blue Rag	7	9	170	2
	Soft Brown Stone	1	3	171	5
	Hard Stone	10	7	182	0

BRADFORD. Rosse Street Brewery (Spinks). 1876.

Made and communicated by Messrs. LEGRAND and SUTCLIFF.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Dug Well (the rest bored)		—		60	0
[Coal Measures]	Black Stone	10	6	70	6
	Hard Light [-coloured] Stone	10	3	80	9
	Blue Stone and Clay	3	3	84	0
	Hard Stone	8	6	92	6
	Dark Soft Stone	2	0	94	6
	Hard Stone	5	6	100	0

BRADFORD. Messrs. C. Taylor and Son. 1876.

Made and communicated by Messrs. LEGRAND and SUTCLIFF.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Dug Well (the rest bored)		—		37	0
[Coal Measures]	Stone	3	9	40	9
	Sand and Iron [-stone]	1	0	41	9
	Dark Stone	8	0	49	9
	Sand	0	9	50	6
	Stone	24	6	75	0

Elland. Spa Field Mills.

Made and communicated by Messrs. Isler and Co.

Good supply. Yield, 23 gallons a minute.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
	Pit (the rest a boring, of 6 inches diameter	—	—	5	0
[Coal Measures]	Clay and Rock	11	0	16	0
	Blue Clay and Shale	5	6	21	6
	Shale and Coal	6	0	27	6
	White Clay	7	6	35	0
	Rock	17	9	52	9
	Blue Rag	1	0	53	9
	Rock	117	3	171	0
	Shale	8	10	179	10

Esholt. For Mr. I. Barker.

Made and communicated by Messrs. Isler and Co.

Yield, 20 gallons a minute.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
	Pit (the rest bored, 5 inches diameter)	—		8	0
	Gravel and Stones	18	0	26	0
[Coal Measures]	Sand and Stone	17	0	43	0
	Rock	18	6	61	6
	Limestone	7	6	69	0
	Light [-coloured] Shaly Rock	11	0	80	0
	Rock	22	4	102	4
	Sandstone Rock	3	0	105	4
	Rock	18	0	123	4

Holfield (near Doncaster). Mr. W. Winder.

From Mr. Crawford.

Water-level, 4 feet 6 inches down. Yield, 13½ gallons a minute.

	Thickness. Ft.	Depth. Ft.
Dug Well (the rest bored)	—	12
Already bored	—	25
Red Sandstone	51	76

KEIGHLEY. The Keighley Fleece Mills Co.

Made and communicated by Messrs. ISLER and Co.

Water-level, 47 feet down. Water tapped at 72 feet rose 5 feet from surface; over-flowed at 100 feet at the rate of 200 gallons an hour; at 123 feet at the rate of 420 gallons an hour; at 133 feet at the rate of 720 gallons an hour. At 218 feet fresh springs tapped, water lowered to 43 feet down.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
	Well (the rest bored)	—		5	0
[Drift]	Ballast [Gravel]	7	0	12	0
	Sand and Ballast	14	0	26	0
	Blowing Sand	12	0	38	0
	Large Boulders and Clay	32	0	70	0
[Coal Measures]	Shale and Clay	5	0	75	0
	Clay and Stones	—		—	
	Shale	22	0	97	0
	Rocky Shale	3	0	100	0
	Rock	4	0	104	0
	Millstone Grit	3	0	107	0
	Rock	22	0	129	0
	Blue Rock	4	0	133	0
	Rock	50	6	183	6
	Millstone Grit	9	6	193	0
	Blue Rock	6	0	199	0
	Millstone Grit	28	3	227	3
	Rock	64	4	291	7
	Rocky Shale	46	8	338	3
	Rock	1	3	339	6
	Rocky Shale	15	9	355	3
	Rock	2	9	358	0

KIRKSTALL. The Kirkstall Brewery Co.

Made and communicated by Messrs. ISLER and Co.

Water-level, 43 feet down. Yield, 72 gallons a minute.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Pit (the rest a boring, of 6 inches diameter)		—		49	0
[Coal Measures]	Shale and Slate	11	0	60	0
	Shale	15	0	75	0
	Rock	5	0	80	0
	Shale	9	0	89	0
	Fire Clay	1	6	90	6
	Rock	9	6	100	0
	Shale	29	0	129	0
	Rock	1	0	130	0
	Shale	4	0	134	0
	Rock	2	0	136	0
	Shale	20	0	156	0
	Rock	1	0	157	0
	Shale	5	0	162	2

LEEDS. 26, Kirkstall Road. (Mr. A. Wright). 1880.

Made and communicated by Messrs. LEGRAND and SUTCLIFF.

Yield, 36 gallons a minute.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Gravel		8	6	8	6
[Coal Measures]	Sandstone	1	2	9	8
	Blue Stone	8	6	18	2
	Hard Light-coloured Stone	5	7	23	9
	Coal	1	0	24	9
	Blue Rag	6	9	31	6
	Black Shale	5	4	36	10
	Hard Blue Rag	8	2	45	0
	Black Shale	10	6	55	6
	Blue Rag	5	8	61	2
	Black Shale	5	11	67	1
	Brown Rag	1	2	68	3
	Black Shale	1	4	69	7
	Blue Rag	2	0	71	7

MIDDLESBOROUGH. The Middlesborough and District Mineral Water Co.

Bored and communicated by Messrs. ISLER and Co.

Water-level in the well 31 feet down, in the bore-hole 38 feet. Supply, about 1000 gallons an hour.

		Thickness. Ft.	In.	Depth. Ft.	In.
	Dug Well (the rest bored)	—		33	0
	Sand and Gravel	27	0	60	0
[Trias]	Dark Blue Clay	9	0	69	0
	Blue Marl and Gypsum	7	0	76	0
	Red Marl with beds of Rock	22	6	98	6
	Hard Marl and Rock	2	0	100	6
	Hard Rock	5	0	105	6
	Red Marl and Rock	36	6	142	0
	Red Sandstone	23	0	165	0

ROTHERHAM. Alum Co. From Mr. CRAWFORD.

		Thickness. Ft.	In.	Depth. Ft.	In.
[Coal Measures]	Loose Rock	7	0	7	0
	Solid Rock	12	0	19	0
	Coal	1	0	20	0
	White Clay	20	0	40	0
	Hard Blue Clay... nearly	16	6	56	6

DESCRIPTION OF TWO NEW SPECIES OF GASTROPODA FROM THE UPPER LIAS OF YORKSHIRE. BY REV. JOHN HAWELL, M.A.

(Read 29th October, 1896.)

PLATE XXXV.

During the visit of the Yorkshire Geological and Polytechnic Society to Whitby, early in August last, two species of Gastropod Shells were found in the Upper Lias, both of which appear to be not only new to the Yorkshire Lias, but, so far as I have been able to ascertain, new to science. Both of these were found in the Jet Rock, or zone of *Ammonites serpentinus*, at Saltwick Nab, near Whitby. The interest of these discoveries will be appreciated when the following facts are borne in mind: first, that the Palæontology of the Upper Lias of Yorkshire, and especially of the Whitby neighbourhood, has been very exhaustively worked out, especially as regards conchology, and that very little has been added since the publication of Messrs. Tate and Blake's admirable work on the "Yorkshire Lias"; secondly, that these authors are only able to record two species of *Gastropoda* as having been found in the zone of *Ammonites serpentinus* in Yorkshire, namely *Natica buccinoides*, and *Euomphalus minutus,* although special facilities have been afforded by the mining of jet. It is also a very notable circumstance that both of these species were discovered by a lady—Mrs. Kendall.

ACTÆONINA KENDALLII, SP. NOV.

The first discovered of the shells referred to is a species of *Actæonina,* of which the following is a *diagnosis:—*

Shell thin, ovate, whorls three, shoulder of whorls almost a right angle ; space between suture and shoulder convex ; spire short ; about 15 well-defined impressed spiral *striæ* on the last whorl, at pretty regular distances apart ; the space near the suture is, however, free from these striations, the uppermost of them coming just below the shoulder ; fainter intermediate impressed *striæ,* varying in number from none to three, and irregular in their position and degree of definiteness ; growth lines fairly well pronounced ; commencing from the suture they curve forwards so as to form an angle of about forty-five degrees with the *carina* at the shoulder ; this forward curving is continued until they reach the middle of the whorl when they bend backwards. The lines of growth are interrupted by the larger *striæ*, but some of the stronger growth lines cross some of the secondary striations without interruption. Length four millimetres, width three millimetres.

Four specimens were obtained, but none of them are in very satisfactory condition. The shells are pyritous. As they were discovered by Mrs. Kendall and communicated to me by Professor Kendall, who is doing so much for Yorkshire Geology, I propose for the species the name of *Actæonina kendallii.*

TURBO SALTVICIENSIS, SP. NOV.

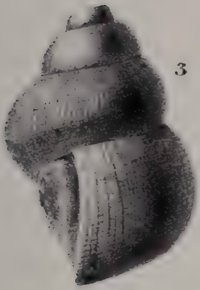
The other new Gastropod which I have to bring to your notice is a *Turbo,* of which the following is a description :—

Shell a truncated cone with four evenly rounded whorls ; apex very obtuse, the primary whorl being almost discoidal ; suture moderately deep ; base slightly flattened ; umbilicus well pronounced, but shallow ; mouth nearly round, but rather pointed at the suture ; peristome not continuous ; outer lip very thin ; columellar lip slightly reflected at the suture ; spiral *striæ* very numerous, fine, and regular, crossed by the lines of growth, which are about equally close set, fine, and regular. Shell in its present condition very thin. Height one and a-half millimetres, width one millimetre.

Some pieces of shale, obtained at Saltwick, are crowded with these little shells, of which I noticed at least one hundred and forty. They are pyritous, and exteriorly in excellent condition. The internal nacreous portion of the shell has, however, been dissolved, though it appears in some instances to give a whitish crystalline appearance to the internal cast when the shell is broken away, especially in the upper whorls. I propose for this species the name of *Turbo saltviciensis,* from Saltwick, the place where it was found.

One specimen resembles the type, except that it has three ridges on the last whorl. This variety may be named *tricarinata.*

3



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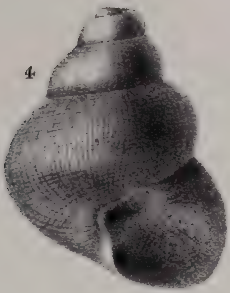

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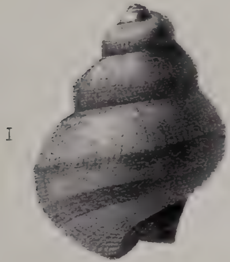

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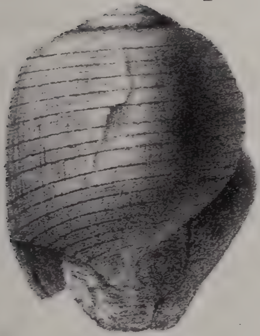

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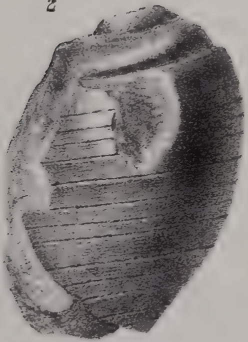

×10

Geo. West & Sons lith. et imp.

1·2. Actæonina Kendallii.
3·4. Turbo Saltviciensis.
5. " " var. tricarinata.

ANCIENT BRITISH STAR-WORSHIP INDICATED BY THE GROUPING OF BARROWS. BY J. R. MORTIMER.

(Communicated 29th October, 1896.)

PLATE XXXVI.

The 196 barrows shown on the accompanying diagram form a selection taken from 292, which occupy an area of about 120 square miles on the Yorkshire Wolds. They are mainly arranged in sixteen groups, all of which I have opened. These groups (copied from the six inch O.S.) are placed on the diagram in the same relative positions to the cardinal points of the compass as they occupy on the surface of the ground. But, to save space, the groups are brought comparatively nearer to each other on the diagram, and are not shown in their true relative positions to each other. Also, in some of the groups, a few of the straggling barrows are left out of the diagram, as the following table will show, and the scattered and unrecognisable arrangements of the mounds of five of the groups are altogether omitted.

As laid down on the Ordnance Survey Maps, the barrows are sometimes placed along an old trackway, either somewhat in a single line, or arranged after a definite figure, as shown in the centre of Group No. 1. They also occur more massed together, but, even in this case also, they are often placed in well-defined figures, formed by the placing of six to eight mounds, as shown on the diagram.

Table showing the Number of Barrows in the Sixteen Groups; also the Number of Barrows included in the Figures on the Diagram:—

Group	1	consists of	20	barrows,	of which	14	are shown on	the diagram.
,,	2	,,	10	,,	,,	0	,,	,,
,,	3	,,	35	,,	,,	32	,,	,,
,,	4	,,	17	,,	,,	17	,,	,,
,,	5	,,	19	,,	,,	19	,,	,,
,,	6	,,	21	,,	,,	7	,,	,,

Group	7	consists of	18	barrows, of which	18	are shown on the diagram.
,,	8	,,	18	,, ,,	15	,, ,,
,,	9	,,	14	,, ,,	14	,, ,,
,,	10	,,	3	,, ,,	0	,, ,,
,,	10½	,,	6	,, ,,	0	,, ,,
,,	11	,,	36	,, ,,	30	,, ,,
,,	12	,,	8	,, ,,	0	,, ,,
,,	13	,,	20	,, ,,	20	,, ,,
,,	14	,,	19	,, ,,	0	,, ,,
,,	15	,,	28	,, ,,	10	,, ,,
			292		196	

This juxta-placing of the barrows at the time of their erection was not an unintentional fact; neither was their arrangement into a definite figure without some well understood meaning. We cannot, however, expect to find that the first copy of the model has remained perfect everywhere. So many of the barrows have been destroyed since their erection; besides, in several instances, from various causes, most probably, the group was never completed. Still we are able, in many of them, to make out with tolerable certainty that the design that has been copied in the arrangement of the barrows in several of these groups has been after the same model.

This figure, so constantly repeated by the intentional arrangement of the barrows, bears an unmistakable resemblance to that of "Charles' Wain" in the Constellation "Ursa Major."

We find in Group No. 1 in the diagram, two of these figures clearly shown, and placed in a line with their broad ends in nearly opposite directions, one to the north-east, the other to the west. Each figure contains the seven representative mounds, corresponding to the seven stars of "Charles' Wain" and no more.

The plan of the ten mounds in Group No. 2, probably from some of them having been levelled down, is not quite clear, and, therefore, it is not given in the diagram.

Of the thirty-five mounds in Group No. 3, thirty-two are arranged into five somewhat undefinable clustres. Each of these, however, seems to show an unmistakable intention of forming the same figure, although not one is now entire, which is probably due either to the removal of some of the mounds, or to the original design never having been carried out.

However, the seventeen barrows forming Group No. 4 make two perfect figures of the Constellation already mentioned, and are placed somewhat in a line, with their narrow ends in opposite directions, namely east and west. The most easterly of these two figures contains, besides the seven mounds, an additional one, which may be said to correspond in position with the small star named Alcor, and only visible on very clear nights near the star at the bend in the shaft of "Charles' Wain." The companion figure to the west exhibits a mound which approximately corresponds to the bright star "Cor-caroli": and there is also a mound between the adjoining ones which correspond to the two stars marked "G" (Gamma) and "Δ" (Delta).

Group No. 5 contains nineteen barrows forming one complete figure, and two others that are nearly so. These figures have their broad ends pointing south-east, north-west, and north-east respectively.

The twenty-one barrows of No. 6 Group are more scattered than those in most of the other groups; yet there is in the centre one clearly shown figure of the seven stars in their relative positions; the remaining fourteen, except one, being more or less collected into undefinable clusters. These are not shown on the plate.

Group 7 comprises eighteen barrows, eight of which are arranged as in the figure of "Charles' Wain," with the broad end to the north. The ten remaining mounds are in two clusters of five each, one of which is arranged like the letter W, after the plan of the five bright stars in "Cassiopeia," similar figures in cup-cuttings are also found on rock surfaces,[*] the other cluster may constitute an incomplete figure of "Charles' Wain," or some other assemblage of stars.

Group 8 is composed of eighteen barrows, seven of which make up a very correct plan of the same seven stars, with the broad end due north. Six other mounds form a nearly completed copy of the same arrangement, but with the broad end in the opposite direction to that of its companion. In addition to these are five other mounds, three at the northern end, which are not shown, and two near the southern end of the group, one of which corresponds to the position of the Pole Star.

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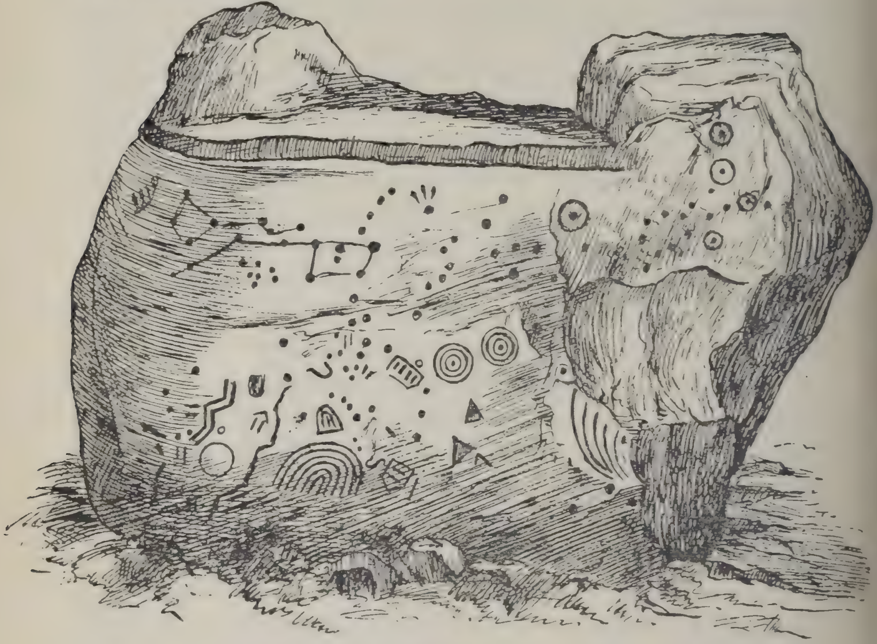
[*] "Sculptured Rocks of Northumberland," by Tate, fig. 4, p. 47.



HAG'S CHAIR, LOUGH CREW, IRELAND.
Enlarged from Rude Stone Monuments, p. 215.

No. 9 is an elongated group, after the form of Group No. 1, and probably in a like manner may follow the course of an old British track-way.

This group consists of fourteen mounds, thirteen of which are included in two nearly complete figures of "Charles' Wain," stretching north and south, with their broad ends towards each other.

Only three scattered mounds now remain within the area of Group No. 10, whilst

Group No. 10½ contains but six mounds, placed mainly in two clusters, but without any definite figure. Neither of these groups is shown on the diagram.

Group No. 11 has thirty-six barrows. The central portion of them only is given on the diagram, and shows nearly three complete figures of this familiar and striking northern group of stars. The remainder of these mounds are placed in twos and threes.

Group No. 12 occupies a site in the immediate neighbourhood of Driffield. Only eight barrows now remain, and they show no definite design, probably from the removal of several of their companions.

Group No. 13 consists of twenty barrows, ten of which are in two clusters, and appear as if they were intended, when completed, to form two of the usual figures. The next eight mounds of this group first suggested to me a perfect plan of "Charles' Wain," with the additional mound to correspond with the star "Cor-caroli," as already described.

There are also two more mounds connected with this figure, one midway between the two barrows which correspond to the two points in "Charles' Wain," the other between the mound corresponding to the more distant pointer-star, and the one at right angles to the line formed by the two pointers. These two additional mounds correspond to two small stars that can only be observed on clear nights. It will also be noticed that the two mounds forming the narrow or shaft end of this, and also three other figures of "Charles' Wain," appear abnormal, as they bend in the opposite direction to the terminal ends of most of the other figures, and of the astral model. This is what would happen in copying the figure of "Charles' Wain" in certain positions, when the direction in the bend of the shaft looks a little uncertain.

Group No. 14 consists of nineteen barrows—not shown on the diagram—in four clusters of four, eight, four, three mounds, respectively in a line. A slight variation of the eight mounds, and a few additions in the three other clusters, would give the figure of "Charles' Wain" I have shown to be so frequent amongst the barrows in this division of east Yorkshire.

In the upper middle portion of Group No. 15 are the ten mounds shown on the plan, seven of which are placed in the readily recognised order that occurs so frequently in the preceding groups.

whilst the three additional mounds hold the same suggestive positions as the two at the broad end of Group No. 13.

The remaining eighteen barrows of this series are not shown on the diagram, but twelve of them seem to make two incompleted figures of "Charles' Wain," the remaining six are more indefinitely scattered.

It will be observed that there are, as previously intimated, a few additional mounds closely connected with some of the figures, but these do not destroy the true arrangement of the seven mounds. After this number had been built, other mounds would often continue to be added, and sometimes in the end the increased number would make the original figure almost indistinguishable. Often, however, several of these superfluous mounds are found (when compared with the constellation they were intended to represent) in the relative positions where on very clear nights corresponding stars may be observed.

This arrangement of five to eight mounds after the figure of "Charles' Wain" is shown to occur more frequently on the area of my investigations than it probably does elsewhere. Most likely this is due to the district having been less tilled, and consequently fewer barrows have been removed, and also to my having restored upon the maps several barrows so obliterated as to have escaped the notice of those engaged on the Ordnance Survey.

In the sixteen groups of tumuli I have opened, there are twenty-three complete or partly complete figures of "Charles' Wain," and one or another of these figures will be observed to occupy almost every varying position "Charles' Wain" takes during the twenty-four hours. Also it will be observed that when two figures occur in the same group, their broad ends point to, or nearly to, the opposite points of the compass. The remaining ninety barrows of the sixteen groups which I have explored, occur singly and in numbers up to five or more, the figure which they were intended to form being undeterminable. Even after the many undoubted removals of the barrows in this neighbourhood, we find the same figure too distinct, and its occurrence far too frequent to be considered accidental.

Its numerous repetitions can only be attributed to the great religious importance in which it was held by the builders of these mounds.

This special arrangement of the barrows, as the following extract from Robert Knox's "East Yorkshire," page 182, will show, is not confined to this district; neither am I the first who has noticed this peculiar figure in the grouping of the British burial mounds. Knox says: —"Near Ugthorpe Rails (seven miles west of Whitby), on that side of the Guisborough road, two stone pillars stand erect, having a cluster of conspicuous houes between, forming the figure of 'Charles' Wain' (in the constellation *Ursa Major*)."

I am inclined to believe that this allusion to the arrangement of the barrows is probably the first ever put in print; it seems to have been mentioned merely as a chance arrangement, as Knox makes no further reference to it.

In hastily looking over some of the Ordnance Maps of other parts of the Yorkshire Wolds, I observed several more or less complete plans of "Charles' Wain," which I need not here describe, and some are named "The Seven Howes."

I have also referred to the six-inch maps of part of the Wiltshire Downs, and noticed that the numerous barrows in the immediate neighbourhood of Stonehenge are, like the barrows I have myself excavated, arranged in clusters. I also recognised in several of these clusters the more or less complete figure of "Charles' Wain." Here also are groups named "The Seven Barrows."

It is not improbable that a carefully constructed map of the barrows of other counties would show that this arrangement was frequently adopted by the barrow builders in most parts of Europe, and is also traceable in some of the North American groups.

From plans of the works of Port Azallan and of the Hutsonville (Illinois) mounds, given in Foster's "Prehistoric Races of the United States of America," pages 136 and 139, there appear to be three or more figures of "Charles' Wain" traceable in the two crowded groups of mounds there shown.

Also, very probably, this placing of the burial mounds after this figure would be found, if carefully made plans of other groups of tumuli in distant countries were looked over. This figure of "Charles' Wain," which has so often been repeated in the arranging of the burial mounds of the dead, has also been in early times sculptured on stone. Mr. B. Boynton, of Bridlington Quay, has an artificially formed ball of hard chalkstone, about two and a-half inches in diameter, on which are six cup-cuttings placed so as to form the same design, except that the cup, to complete the shaft of the Wain, is absent. Probably this stone was a hand weapon, on which this symbol was engraved as a charm. We also find this figure among the cup-formed sculpturings on our dolmens and on various rocks.

"Hag's Chair"* (fig. 1) is a large block from a circle of stones which surrounded the base of a cairn at Lough Crew, Ireland. It is thickly covered with cup and other incised mystic symbols.

These were probably meant to represent the appearances of the various heavenly bodies, such as the sun, moon, stars, and other astronomical objects. Certainly the seven stars of "Charles' Wain" are unmistakably shown to be mapped in two distinct figures, arranged in positions indicating half a revolution round the Pole, and almost identically similar to the placing of some of the groups of barrows on the diagram.

That the two groups on "Hag's Chair" of seven cups each were intended to form the figure of "Charles' Wain" is clearly shown by the cups alone in each figure being distinctly connected by an incised line. A little below the two figures of "Charles' Wain" on "Hag's Chair" are seven other cups arranged in much the same manner as the stars of the Pleiades. The rising and setting sun seem to be shown, and the circles within circles, varying in size and number, may have been cut to symbolise the Planets, while the nearly vertical zigzag lines were probably meant to indicate flashes of lightning. Altogether the symbols on this stone seem to point to fire and star worship; and the grouping of the barrows indicate an adoration of the same objects.

Stones similarly decorated have been noticed in other countries. "Prince Putiatin has presented to the Russian Archæological Society a stone slab which was recently found in the course of some excava-

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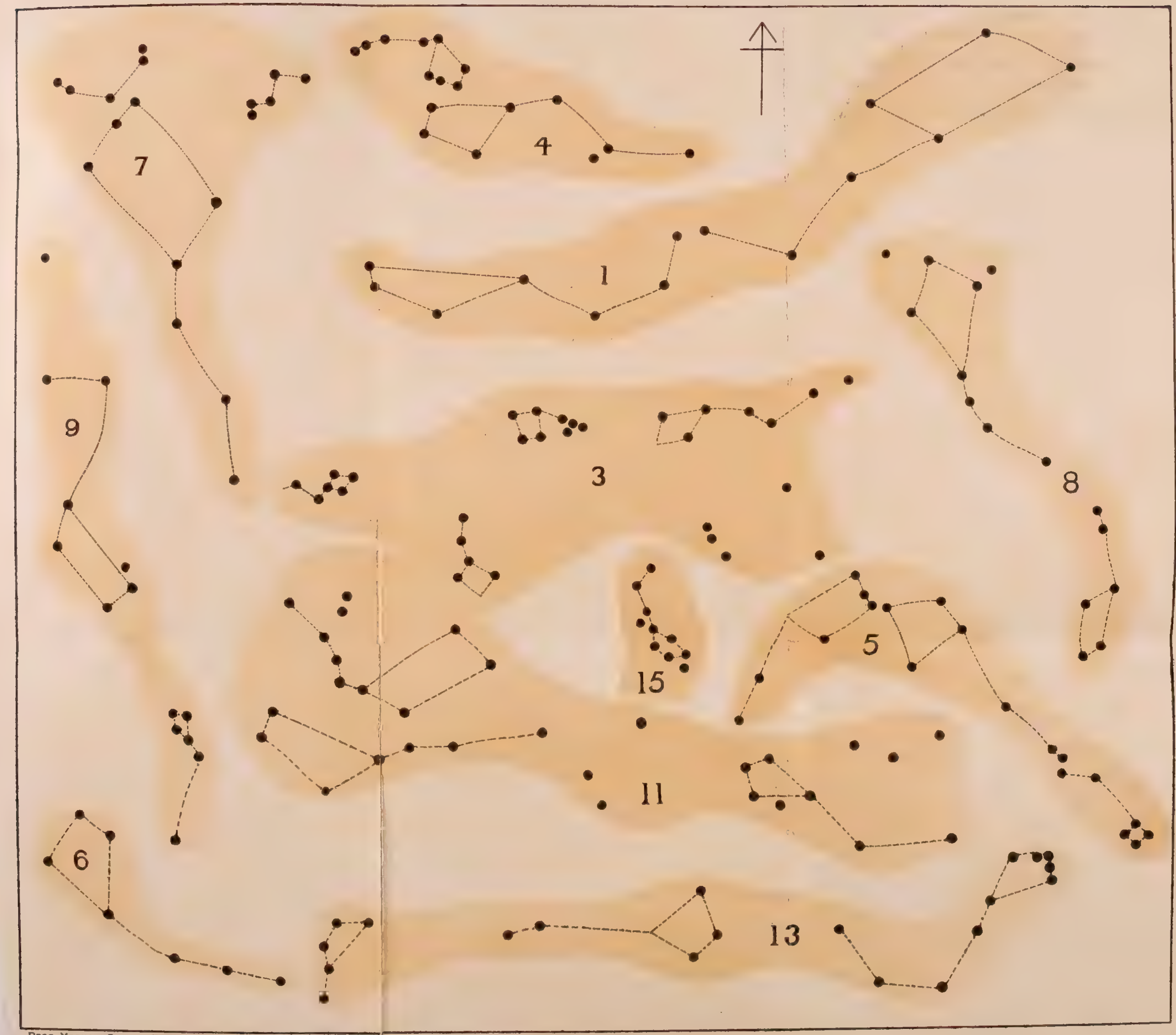
* Copied from "Rude Stone Monuments," fig. 73.

Groups of Barrows near Sledmere and Fimber, East Yorkshire.



PROC. YORKSH. GEOL. & POLYT. SOC., VOL XIII., PLATE XXXVI.

THE ABOVE GROUPS ARE PRICKED FROM THE 6-IN. O.S.

tions at Boulogne Station, on the St. Petersburg and Moscow Railway, along with some weapons and utensils. A representation of the Constellation of the *Great Bear* was, though rudely, yet carefully, drawn on the slab.* It may be remembered that some years ago a similar slab was found near Weimar."† This same symbol was also adopted by the ancient Greeks. We are told by Homer that on Achilles' shield was figured "Charles' Wain," the sun, moon, and all the signs that crown the vault of heaven. Probably many of these figures were but slightly dissimilar to the symbols on "Hag's Chair."

The object of arranging the barrows and cup-markings after the figure of "Charles' Wain" can only have one explanation, that object being evidently a religious one. The stars of this Constellation, swinging diurnally round the Pole star, were, to primitive man, an unerring as well as a perpetual timepiece, and would be revered as a *something* divine.

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* These slabs had most probably been taken from dolmens.

† The "English Mechanic," Sept. 24th, 1886.

NOTE.—"On the capstone of a dolman, near the village of Runusto, are several cup-markings resembling somewhat the Constellation of Ursa Major." Guide to Chambered Barrows of Brittany, p. 23, by W. C. Lukas.

NOTES ON THE DRIFTS OF THE HUMBER GAP. BY J. W. STATHER, F.G.S.

(*Read August 1st, 1896.*)

PLATE XXXVII.

The glacial and post-glacial deposits of South-east Yorkshire and North Lincolnshire are divided naturally into separate areas by the range of the Chalk Wolds, connected only by the narrow strip of drift which passes through the Humber valley. Good sections in this strip occur on both sides of the river, at North Ferriby and South Ferriby. In these sections the different beds described in the context are revealed, but are best seen in the winter after stormy weather. The Ferriby sections have been noticed by several observers, and references to them will be found in the works of S. V Wood,* Jukes-Browne,† and the Memoirs of the Geological Survey.‡ The South Ferriby section is fairly well described by Messrs. A. J. Jukes-Browne and C. Fox-Strangways in the North Lincolnshire Memoir above referred to, but of the cliff at North Ferriby no adequate account has yet been published. Inasmuch as these sections occur directly in the constricted portion of the Humber Gap, in drifts linking the glacial deposits east of the Wolds, with those of the less known region to the west, and are the only extensive sections visible for many miles, a fuller description of them may prove useful to glacialists studying the district.

PHYSICAL FEATURES OF THE DISTRICT.

The featureless flats of glacial and recent deposits which border the Humber east of the Wolds seldom rise much above the level of spring tides, and one consequently looks in vain for cliffs or sections. From Paull westwards, on both sides of the Humber for twelve miles, the dead-level of the warp deposits continues till North and South Ferriby are reached. (See map.)

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* S. V. Wood and J. L. Rome On the Glacial and Post-glacial Structure of Lincolnshire and South-east Yorkshire. Quart. Journ. Geol. Soc., vol. xxiv., p. 146.

† A. J. Jukes-Browne. On the Southerly Extension of the Hessle Boulder-clay in Lincolnshire. Quart. Journ. Geol. Soc., vol. xxv., p. 397. The Boulder-clays of Lincolnshire; their Geographical Range and their Relative Age. Quart. Journ., Geol. Soc., vol. xli., p. 114.

‡ Survey Memoir, North Lincolnshire.

At North Ferriby the land rises somewhat abruptly, and the bank of the river becomes a low cliff which continues for half-a-mile or so, and then sinks, though much more gradually than it rose, to its former level, under the recent river warp to the west. This cliff, which is at present receding somewhat rapidly under the erosive action of the Humber, is locally known as Red Cliff. It has an average height of 16 or 18 feet, with an extreme height of 25 feet. The only previous description of the section known to me, is that of Mr. Cameron, who, however, mentions only that "At the low cliff of North Ferriby there is a purple chalky boulder clay, the upper part of which weathers red."*

The cliff at South Ferriby also rises somewhat suddenly from the eastern flats, attains a height of 20 feet, and then gradually sinks towards the west. The length of the section is about two-thirds of a mile. Of this section Mr. Clement Reid remarks, "The low cliff of South Ferriby is the only exposure of boulder clay on the south shore of the Humber. It corresponds closely with that seen at North Ferriby, and exhibits a boulder clay separated from the Chalk by thin ripple-marked flaggy sandstone. From this point eastward, boulder clay forms a belt separating the Chalk Wold from the Humber flat, clearly showing that the ancient Humber valley was not only deeper but wider than the present one, and was subsequently filled with drift, through which the present river is excavating its channel."†

DESCRIPTION OF THE BEDS.

10. CHALK.—At South Ferriby, the solid Chalk which forms the base of the middle part of the section, and also the adjacent beach, belongs to the Lower Chalk. It is a hard grey rock with pink bands (fig 10).

8. RIPPLED SANDSTONE.—Interposed between the boulder clay and the rubbly top of the solid Chalk in the South Ferriby cliff

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* Survey Memoir, Holderness, p. 19.

† Survey Memoir, Holderness, p. 51.

(section B, fig. 10), is a thin ripple-marked sandstone. The section near the little house is described by [*]Mr. Jukes-Browne, as follows:—

	Feet.
"Boulder Clay	10
Red-brown Clay and Light-coloured Sand, interlaminated and resting on a layer of hard rippled Sandstone	1
Coarse Gravel of large round stones, Grey Chalk and Red Chalk among them, seen for	1."

The sandstone appears to be somewhat intermittent, but the coarse gravel is always present, and I noticed recently at this horizon, partly incorporated with the base of the sandstone, large rounded pebbles of granite, Mountain Limestone, whinstone, &c., showing that the deposit belongs to the glacial series.

7. LOWER BOULDER CLAY.—This is a hard tough boulder clay, of greyish purple colour, containing many erratics, and here and there a pocket of sand or crushed chalk. It is best seen on the northern side of the Humber, at the Red Cliff section (A), where it forms the beach and occupies the lower part of the cliff for two-thirds of its length (figs. 2, 3, 4 and 5). Under favourable conditions this clay is readily distinguishable by its colour and texture from the other members of the series ; and in both sections (A and B) its upper surface is extremely uneven and hummocky.

At South Ferriby, the Lower Clay occurs only at the base of the cliff between the jetty and the house (fig. 9), while further west where other glacial deposits can be seen to rest upon the Chalk, well above beach level, it cannot be traced (fig. 10).

6. LAMINATED CLAY.—A beautifully laminated dark-grey clay, of fine texture, ripple-marked in places and almost entirely free from pebbles, occurs in isolated patches, and appears to occupy hollows in the upper surface of the Lower Boulder Clay. It is best seen at the eastern end of the Red Cliff section, where it occurs both in the cliff and on the beach (figs. 5, 6 and 7).

5. UPPER BOULDER CLAY.—This deposit which is well represented both at Red Cliff and South Ferriby, is a foxy-red boulder

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[*] Survey Memoir, North Lincolnshire, p. 150.

clay of earthy texture, with bluish or ash-coloured joint-planes. In a clean unweathered surface the redness is seen to be uniform throughout the deposit, and a sharp and definite line of separation from the underlying clay (7) can generally be traced. The boulders in this clay are smaller and fewer in number than in the Lower Clay (7), and at Red Cliff, chalk pebbles seem to predominate, but the usual far-travelled types are also present, generally deeply weathered, and sometimes scratched. Referring to the diagram (A), it will be seen that this bed, near the middle of the section comes to a somewhat abrupt termination, its place in the cliff being taken by the High Level Warp Series (fig. 4). There is no sign here of the one bed passing into the other, the junction is perfectly clean and sharp, and is probably due to erosion.

4. HIGH LEVEL WARP AND SANDY SERIES.—This series attains a considerable development in the Red Cliff section (figs. 5 and 6). It is a well-bedded deposit of sandy warp, passing now and again into almost pure sand, a fact which a colony of sand martins are not slow to recognise. Its position with regard to other beds in the section is somewhat peculiar. Eastwards it rests on the laminated clay (6), with which it is mingled to produce the intermediate bed described below (figs. 5 and 6). In other places it rests on the Lower Clay (7), excepting at its extreme western extension (fig. 4), where it overlaps the Upper Clay, and finally thins out (fig. 4).

4a. INTERMEDIATE BED.—This peculiar bed comes between the Laminated Clay and the High Level Warps. It persists for a long distance in the Red Cliff section, attaining a thickness of three or four feet in places (figs. 5 and 6). It is apparently made up of rolled fragments of the one bed embedded in a matrix of the other; and in section has a very characteristic appearance, caused by the inclusions falling away and leaving the matrix in relief, in the form of cups and hollows (fig. 13).

3. FLOOD GRAVEL.—Capping the highest part of Red Cliff, and resting on the Warp and Sandy Series, is an irregular gravel, chiefly chalk, but also containing rounded pebbles of grit, granite, rhomb porphyry, etc. (fig 5).

2. CHALK VALLEY GRAVEL.—At South Ferriby, west of the house, at the point where the Upper Clay dips below beach-level (fig. 10), the continuation of the cliff shows a chalky, gravelly clay, which gradually passes into pure gravel, consisting of angular and sub-angular bits of chalk and flint, containing at first, a few foreign pebbles, but further west the foreign element dies out entirely (fig. 11). From the Wold overlooking the section from the south, the gravel can be seen to occupy a delta at the mouth of a shallow Chalk valley, which the Humber intersects.

(Although discussion of the forest-beds of the Humber district is not within the scope of the present paper, it may be well to note that on the foreshore on both sides of the river, immediately to the west of the sections above described. patches of peat occur, containing trunks of trees, bones, etc.)

THE BOULDERS.—The Red Cliff clays are rich in erratics, and the shore below the section is strewn with boulders varying from the size of a pebble to two or three feet in diameter, derived from the rapidly wasting cliff. The following list of boulders, derived chiefly, I believe, from the Lower Clay, is compiled from my notes:—

Granites, many distinct types, chiefly pink.
*Shap granite (S. Ferriby).
Augite syenite (laurvikite of Brogger).
Rhomb porphyry, several varieties.
Porphyrites.
Basalts.
Amygdaloidal-basalt.
Dolerite.
Mica Schist.
Garnetiferous schist.
Gneiss of various kinds.
Quartzite.
Vein quartz.

SEDIMENTARY ROCKS.

Grits
Conglomerates } Probably Pre-Carboniferous.
Greywacke

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*Notes on the occurrence of Shap Granite in Lincolnshire by Thos. Sheppard, Naturalist, November, 1896.

Fossiliferous limestone, containing Spirifer, Productus giganteus, Lithostrotion, syringopora, etc.	Carboniferous.
Ganister	
Sandstones in great variety	
Pale, hard Magnesian Limestone	Permian.
Mottled limestone (Roker type)	
"Brockram" conglomerate from the Eden valley	
Fossiliferous limestone	Lias.
Septarian nodules	
A. communis	
A. bifrons	
A. fibulatus	
A. crassus	
A. semi-costatus	
A. sub-armatus	
Bels. sp.	
Hippopodium ponderosum	
Cardinia sp.	
Gryphoea incurva	
Oolitic limestone (with fossils)	Oolites.
Black shale with crushed fossils	Kimeridge.
Exogyra sinuata	Necomian.
B. lateralis	
B. jaculum	
White chalk	Cretaceous.
Red chalk	
Iron pyrites	
Black flint (not local)	
Pink flint (not local)	
*Belemnitella lanceolata (Schlotheim) not recorded from the Yorkshire Chalk	
Green coated flint (Eocene ?).	

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* For the determination of this species, of which I have five specimens from Red Cliff and others from the Holderness clays, I am indebted to Mr. A. J. Jukes-Browne.

During the summer of 1896, 373 boulders of 8in. and upwards in diameter were noted in the cliff and on the adjacent beach, the rough classification of which yields the following results:—

		Per cent.
69	Carboniferous Limestones	18·5
104	Sandstones, Grits, Conglomerates, &c., probably nearly all from Carboniferous or other Palæozoic Rocks	27·9
49	Sandstones, &c., probably nearly all of Mesozoic Age	13·1
21	Lias	5·9
10	Chalk (including four black flints)	2·6
88	Basaltic and other Eruptive Rocks	23·5
32	Granites, Schists, Gneiss, etc.	8·5
373		100·0

A great resemblance is at once perceived between the above lists of boulders and similar records from the boulder clays of the Holderness coast, especially those taken from the basement series of Bridlington and Dimlington.* And considering that none of the boulders from the Red Cliff section (as far as I am aware), have been referred with certainty or even probability to sources west of the Wolds, but on the other hand almost all the specimens met with can be matched from the drifts of the coast sections, it can scarcely be doubted that the Ferriby and Holderness boulder clays belong to the same series, and have had a common origin.

Considering the proximity and relative position of the Wolds to the Ferriby glacial sections, the low percentage of local Chalk amongst the boulders is quite remarkable, and indicates that the material of which the clays are composed is almost entirely of distant origin. It will be noticed that Belemnitella lanceolata from the Chalk found in the clays, is not known as a Yorkshire Chalk fossil, and that the flints are different from those in the Yorkshire Chalk. On the other

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*Lamplugh, Drifts of Flambro' Head.—Quart. Journ. Geol. Soc., vol. xlvii.
,, Glacial Sections near Bridlington, pt. iv., Proc. Yorksh. Geol. and Polyt. Soc., vol. ix.
British Association Erratic Block Committees Reports, 1895 and 1896.
Transactions Hull Geological Society, vols. i. and ii.

hand Belemnitella quadrata, a common fossil in the Yorkshire Chalk, I have not seen.

Two or three years ago, the erratics scattered on the beach below the Red Cliff section, presented in small compass as fine a natural collection of ice-scratched boulders as one could wish to see, owing no doubt to the gentle treatment of the kindly Humber, as compared with the rougher wave action on the Holderness beaches. Boulders of the well-known Scandinavian types were then not at all uncommon, but they are now decidedly rarer owing possibly to the local geologists, on whom seems to have fallen the mantles of those ancient Vikings, whose delight it was, according to some authorities, to carry these stones from place to place.

Among the many boulders imbedded in these clays I have been unable to detect any definite orientation of the longer axes On the other hand both here and elsewhere in Holderness, where I have studied this point, it has appeared to me that the boulders are arranged at random in this respect, and without any sign of agreement.

The boulders of igneous and far-travelled rocks from the Upper Clays of this district have (I think) generally a more weathered appearance than specimens of the same rocks from the Lower Clays. Basalts and other close-grained rocks are often coated with a rusty skin, entirely concealing their identity until the hammer is used, and the smaller boulders of granite and other coarsely crystalline rocks are often rotten throughout. On the other hand the same class of rocks from the Lower Clays are comparatively fresh and unweathered, The fact that these weathered boulders occur in the Upper Clay and, therefore, have been more exposed to post-glacial atmospheric agencies, scarely accounts for the excessive weathering and oxidation they appear to have undergone. For in the clay side by side with these deeply weathered specimens of the harder rocks, we find pebbles of chalk in abundance, which surely should have disappeared long ago had the disintegrating forces to which they were exposed been as great and prolonged as the weathered coats of their harder companions seem to suggest.

It seems not improbable that these weathered boulders of the Upper Clays have been derived at second-hand from the destruction of the Lower Clay.*

NOTES ON THE CORRELATION OF THE BEDS.—The difficulty and uncertainty attending the correlation of glacial deposits, always great, is necessarily increased when, as in the present case, the sections under discussion are isolated and far away from other exposures. Yet the characteristics of some of the beds just described are sufficiently marked and definite to invite and perhaps to justify comparison with other areas and sections. Besides it has been the opinion of observers from the time of Messrs. Wood and Rome onwards (for discussion of this point see Mr. G. W. Lamplugh's paper on "The Drifts of Flamboro' Head"), that well-marked divisions in the drifts exist and persist over wide areas, including Flambro' Head, Holderness, and perhaps Lincolnshire. And it appears almost certain that the deposits seen in the Ferriby sections are continuous with like deposits far beyond the limits of these sections. Thus with regard to the lowest bed, when speaking of the Hessle gravels, Messrs. Wood and Rome observe "at the Hessle quarry, the sand and gravel bed is divided from the brecciated surface of the Chalk by a thin bed of indurated or ripple-marked mud; and at South Ferriby is divided from its superincumbent clay by a similar pan." In further confirmation of the extension of this bed north of the Humber, I may mention that a section recently visible in the railway cutting west of Hessle station exhibited a thin sandstone (ripples not seen) at the base of the boulder clay. So we may conclude that the special conditions which produced the rippled sands at South Ferriby extended at least as far as Hessle on the opposite side of the Humber gap.

Mr. A. J. Jukes-Browne, who has written very fully on the boulder clays of Lincolnshire, has, I think, very justly referred the red earthy Upper Boulder Clay of both the sections described in this paper to the Hessle clay of Holderness, first described under that name by Messrs. Wood and Rome.

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* I am indebted to Mr. G. W. Lamplugh for this suggestion.

A.

SECTION IN THE DRIFTS ON THE NORTH SHORE OF THE HUMBER AT RED CLIFF NEAR NORTH FERRIBY.

LENGTH OF SECTION 2016 FEET.

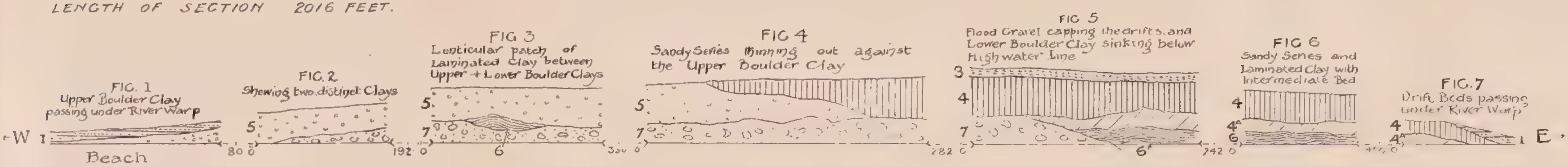


FIG. 1 Upper Boulder Clay passing under River Warp

FIG. 2 Shewing two distinct Clays

FIG 3 Lenticular patch of Laminated Clay between Upper + Lower Boulder Clays

FIG 4 Sandy Series thinning out against the Upper Boulder Clay

FIG 5 Flood Gravel capping the drifts, and Lower Boulder Clay sinking below High water Line

FIG 6 Sandy Series and Laminated Clay with Intermediate Bed

FIG. 7 Drift Beds passing under River Warp?

Scale of Sections 40 Feet to an inch.

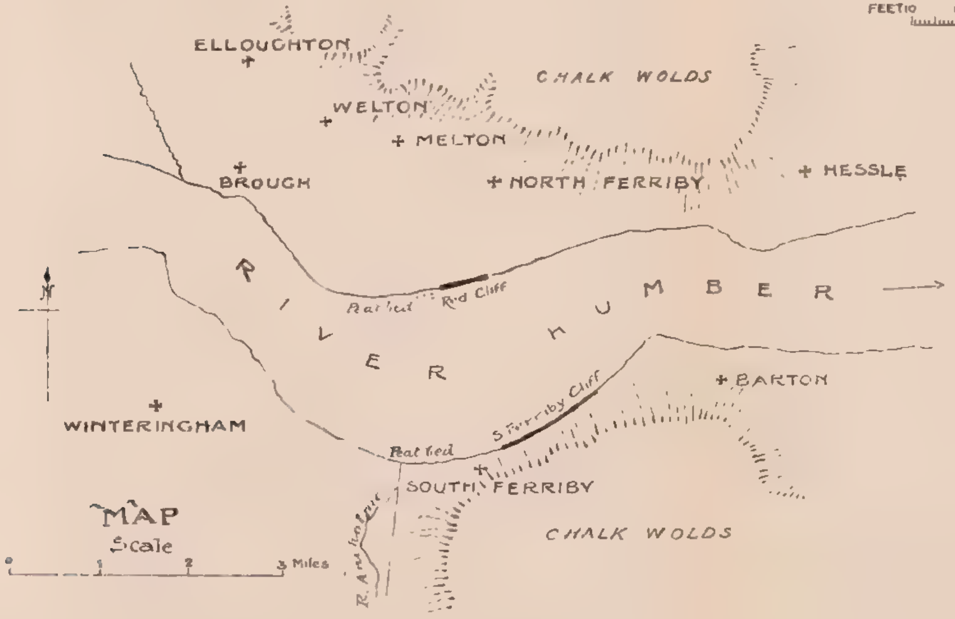
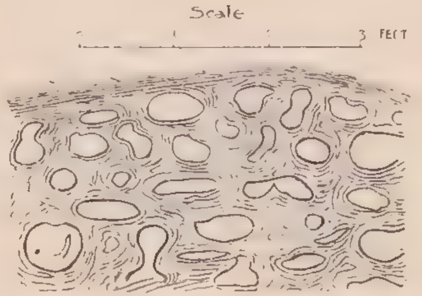

MAP

FIG. 13



Index

Red Cliff Section A		S. Ferriby Section B
BED 1	Humber Warp	BED I
–	Chalk Valley Gravel	" 2
" 3	Flood Gravel	–
" 4	High level Warp and Sandy Series	–
" 4^A	Intermediate Bed	–
" 5	Upper Boulder Clay	" 5
" 6	Laminated Clay	" 6
" 7	Lower Boulder Clay	" 7
–	Rippled Sandstone	" 8
–	Chalk	" X

B.

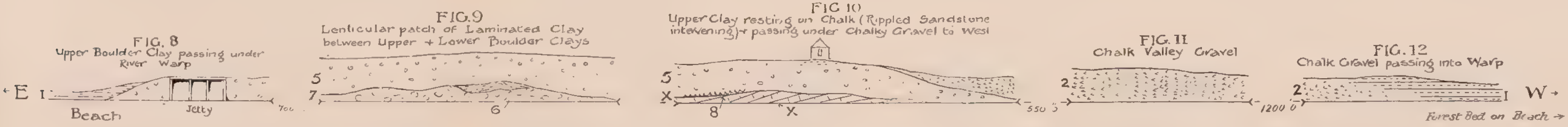


FIG. 8 Upper Boulder Clay passing under River Warp

FIG. 9 Lenticular patch of Laminated Clay between Upper + Lower Boulder Clays

FIG 10 Upper Clay resting on Chalk (Rippled Sandstone intervening) + passing under Chalky Gravel to West

FIG. 11 Chalk Valley Gravel

FIG. 12 Chalk Gravel passing into Warp

SECTION IN THE DRIFTS ON THE SOUTH SHORE OF THE HUMBER NEAR SOUTH FERRIBY.

LENGTH OF SECTION 3600 FEET.

The Lower Clay appears to be a westward prolongation of one of the lower divisions seen on the coast. Its texture, boulders (see above), and associated laminated clays, suggest the basement series of Dimlington and Bridlington, but the deposit has not yet yielded Arctic shells, nor is its colour that of the basement clay of the coast sections. But as the shells have been shown to occur in the basement clay merely as derived "pebbles," their absence in this section may be no more than a local accident ; and also as the colour of the boulder clays, and especially of the basement clay varies according to the material of which it is composed, neither of these differences is of much importance.

At the eastern end of the Red Cliff section, it might appear at first sight that there was a continuous series of laminated and sandy beds from the bottom to the top of the section, but a closer examination seems to show, as already described, that between the Laminated Clay and the High Level Warp and Sandy Series, there is a well-marked line of erosion (figs. 4, 5 and 6). Indeed the latter series makes an unconformable overlap upon the glacial deposits below, since it rests, as mentioned above, first on the Laminated Clay, then on the Lower Boulder Clay a little further to the west, and further still in that direction on the Upper Boulder Clay.

The curious intermediate bed at the base of the High Level Warps, seems to be due to the breaking up of the top of the laminated clay, perhaps when in a frozen condition, and the rolling of the fragments into pebble-like form.

As for the age of the High Level Warps this must for the present remain uncertain. They are clearly newer than the Upper Clay (5), but are older than the Gravel capping the section (3), which the Officers of the Survey regard as the extension of the Brough and Ellerker Gravels, supposed to be of glacial age. This would imply that the Warps themselves are not newer than late glacial times, but as has been pointed out *there is probably in the Vale of York a succession of stratified warp deposits dating from the close of glacial conditions to the present time.

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* Survey Memoir.—The Geology of the Country North-east of York and South of Malton.

The Chalky Gravel (2) of the South Ferriby Section appears to be of the same character as that of the dry Wold Valleys, and to have had the same origin.*

Conclusions.—The following are the chief deductions to be drawn from the facts as above recorded :—

1. The materials which compose the North and South Ferriby glacial sections show conclusively that the agency which produced them did not flow from the higher regions of the Humber valley, as the general shape of the ground and high land to the west would suggest, but came, on the contrary, from the eastward, the material of the deposits agreeing exactly with that of the Holderness sections.

2. The Ferriby Sections reveal an Upper and a Lower Boulder Clay of entirely different types, separated by a line of erosion, probably corresponding to certain wide-reaching divisions of the Yorkshire coast.

3. The detailed study of the sections confirms the view originally put forward by Mr. S. V. Wood, that the glacial beds on the opposite sides of the Humber were once continuous, and have since been cut through by the river.

4. The ridge of glacial material now bi-sected by the Humber at North and South Ferriby, has at one time constituted a much more prominent feature than at present, when it is nearly buried beneath the later warps. Its original outline suggests a moraine-like bar across the Humber Gap.

5. If the Geological Survey are right in referring the gravel capping the Red Cliff Section to late glacial times, the High-level Warp Series overlying the boulder clay cannot be of later date. It would thus agree in stratigraphical position with the Hilderthorp Warps near Bridlington.

6. The position and relations of the glacial beds in this section indicate the former presence of a mass of land-ice in the bed of the North Sea, possessing a tendency to press westward upon the land, the ice west of the Wolds being insufficient to keep back the intruder.

For the diagram illustrating these notes I am indebted to Mr. W. H. Crofts, and for valuable help in many other ways.

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* Survey Memoir.—The Geology of the Country between York and Hull, p. 34.

NOTES ON ELEPHAS ANTIQUUS AND OTHER REMAINS FROM THE GRAVELS AT ELLOUGHTON, NEAR BROUGH, EAST YORKSHIRE.

BY THOMAS SHEPPARD.

Read August 1st, 1896.

PLATE XXXVIII.

About ten years ago Mr. G. W. Lamplugh, F.G.S., read a paper before this Society* in which he mentioned having found a tusk of a mammoth, 10 feet long, and also the tooth of a horse from the gravel pit on Mill Hill, near Brough.

After describing the gravel and remarking as to its probable age and origin, the author went on to say that analogous deposits elsewhere in the Riding contained a larger fauna, and he should at least expect remains of rhinoceros, bos or bison, and cervus to occur in this pit in addition to those of horse and mammoth.

Since first opened the gravel pit has been steadily worked at, but unfortunately Mr. Lamplugh has been unable to pay the attention to it that he would have liked.

On Easter Monday, 1889, the Leeds and Hull Geological Societies visited this neighbourhood, an account of the excursion appearing in the "Naturalist" and the Transactions of the Leeds Geological Society for that year ; but since that date the gravels do not appear to have received the attention from geologists that they deserved.

During the last two or three years, however, a large quantity of bones of different sorts have been obtained, and I have done my best to preserve them, though in most cases I can only reiterate Mr. Lamplugh's complaint that as a rule they are found in a very friable condition. What became of the bones that were unearthed between Mr. Lamplugh's visits and mine I cannot say ; no doubt the workmen had not taken the trouble to preserve them ; in fact one of them told me as much. I am informed, however, that since the previous paper was read its author obtained another, though smaller, tusk, which he presented to the Museum of the York Philosophical Society.

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* Proc. Yorksh. Geol. and Polyt. Soc., vol. ix., 1887, p. 407-411.

Owing to the extensive excavations made during the last few months the gravels are rapidly thinning out, and nowhere exceed nine feet in height ; they were about twice this thickness when previously described.*

At present the section appears as follows :—

Soil	... about 1 ft.
Current-bedded gravel (chiefly local flint and chalk), with occasional foreign pebbles, and in places streaks of sand and carbonaceous material† ...	,, 6 ft.
Very tough earthy sand and gravel, stained with iron-oxide, containing, especially near the top of the bed, quantities of large boulders, chiefly Coal-measure sandstones (with rootlets) and others, which have evidently come from the west ...	,, 2 ft.
Total	... about 9 ft.

The dip of the current-bedding is generally to the south-east.

The gravel rests on an isolated hill of Great Oolite Clay‡ at an elevation of 100 feet above O.D.,|| and at the bottom of the hill the Millepore Limestone is exposed in a small quarry.

Occasionally large slabs of Kelloway Rock and Lias (with Ostrea liassica, etc.) are lying about in the bottom of the pit. Just now there is a large boulder of Whin Sill on the floor, *standing on end*, under the gravel.

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* Op. cit. page 408, which gives :—

Top soil, etc.	2½ feet.
Rough stony gravel, with some sand, etc., about ...	9 ,,
Yellow sand, with stony layers, etc.	5 ,,
Total ..	16½ feet.

† This gravel in places is a good collecting ground for flint casts of galerites, micraster, terebratulæ, etc.

‡ In March, 1895, I had an opportunity of examining a well that was being dug exactly half way up the hill for use at a house near. It showed 6 feet of stiff blue clay, greatly stained with yellow, containing no fossils or stones. Below this was about 3 feet of yellow clay, then water prevented me from seeing further ; but at one end of the heap of excavated material at the top of the well was a quantity of fine yellow sand, which had no doubt come from below the 3 feet of yellow clay. See also "Geology of the County between York and Hull." (Geol. Survey Mem.), 1886, page 22.

|| The 100-feet contour line just circles round the top of the hill.

A few pipes* descend from the soil into the gravel. These have obviously been formed by the percolation of water, which has gradually dissolved the chalky material, allowing the fine particles of sand and soil to fall in.

It frequently happens that the lime thus dissolved is deposited on the surfaces and sides of the boulders and pebbles situated immediately underneath the "pipes," forming a loose conglomerate. Occasionally these deposits of lime present peculiar forms, which may be mistaken for remains of serpulæ or other marine organisms. Indeed they have been held to be such by some visitors to the sections. So far as I have been able to ascertain, however, marine action has had nothing whatever to do with the formation of these gravels.

We will examine the lower gravel of the section a little more closely. This is no doubt the "yellow sand with stony layers . . . . . . about 5 feet" referred to by the previous writer.† It does not occur in all parts of the pit, at present being only found in the north-east corner, where it seems to fill a saucer-like depression in the oolitic clay beneath. It is precisely in this hollow that the before-mentioned relics of the large animals are preserved. This lower gravel, being compact and apparently solidified by oxide of iron, is of a totally different character from the loose chalky material above, which contains no mammalian remains, as it consists of boulders of gannister, millstone grit, etc. It would appear, therefore, as already suggested,‡ to be the remains of a more extensive bed which has been almost entirely removed by denudation ; but how far the deposit extends, or extended, we are unable to ascertain, apparently to no great distance, as the hill on which it rests is not far round at this elevation.

Unfortunately the men are only able to work at the mammaliferous part of the gravel during the summer months, standing water preventing them in winter.

I am pleased to say that the list of animals whose remains are found in these gravels has been increased from two‖ to seven species, though from the appearance of the section it is not likely that very many further additions will be made.* The bones are generally, but not invariably, found at the bottom of the lower gravel, resting on clay, but whether the Great Oolite Clay, or part of the old land-surface, I cannot at present say ; possibly it is both.

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* They are well shown on a photograph kindly sent to me by Mr. Nicholls, of Leeds. See "First Report of the Geol. Photo. Committee of the Yorksh. Nat. Union," Nos. 168 and 169, printed in the "Naturalist" for March, 1891, p. 74.

† Op. cit. page 408. ‡ Op. cit. page 409.

‖ Mr. Lamplugh's List, op. cit. page 410.

Mr. Clement Reid, F.G.S., F.L.S., has been good enough to examine a sample of this clay for me, and states "there is nothing whatever in your clay from Mill Hill except one rolled foram, apparently derivative. The clay has been penetrated in every direction by small root-fibres, and the fossils seem all to have decayed, as the deposit is full of small concretions of race. The one foram is apparently silicified."

As already pointed out, the teeth and bones unfortunately occur in a very friable state. This is especially the case with the teeth and tusks of the older members of the elephant family. I have frequently brought away as much material as could be carried, which consisted entirely of minute fragments of teeth and tusks, and to piece these together is an impossibility.

I had repeatedly asked the men to let me know immediately they came across any specimens, so that it could be seen exactly under what conditions they were found, and once they kept a very large tooth of a mammoth for me to dig out. This, as usual, appeared to be resting on the clay, but was surrounded and covered by the ferruginous gravel, which with some difficulty was cleared away, leaving what was apparently a perfect tooth, lying on its side, and measuring 12 inches by 10 inches, the grinding surface being 7 inches long. Before lifting it, innumerable small cracks could be seen traversing it in all directions, and though every possible care was taken to get it away whole, on being moved it immediately crumbled to pieces, forming a heap of comminuted bone. This tooth, it should be noted, had belonged to a full-grown elephant.

In one or two cases, when the teeth belonged to younger animals, they were in a perfect state of preservation. For example, two teeth of a very young mammoth, which are of precisely similar dimensions, and undoubtedly originally existed in the same skull, were found in close proximity to each other. They have all the sharp corners, etc., preserved, and do not shew the slightest sign of having been waterworn. No trace of the skull could be found; this, being of softer material, having no doubt been dissolved away.

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* A few pieces of bone and a good tooth of Elephas antiquus, however, have been obtained since the paper was read.

In his account of the large tusk found here, Mr. Lamplugh expresses the opinion that it has not been carried far by running water, but has "either been transported from a shore-line by floe ice or has dropped from the floating carcase of some animal," and the finds since made, notably the two small mammoth teeth, do not invalidate this statement. None of the bones yet obtained from this pit shew signs of having been waterworn.

With the kind help of Mr. H. M. Platnauer, B.Sc., F.G.S., of the York Museum, remains of the following animals have been recognised among the bones from the Elloughton gravels, from which it will be seen that, with the exception of Rhinoceros, I have found all the remains Mr. Lamplugh said he should expect to occur here, and others in addition :—

The Mammoth,	*Elephas primigenius* (*Blum.*)	Over a dozen teeth, mostly badly preserved, numerous pieces of tusk, averaging 6 inches in length. One small tusk (2 inches in diameter) in pieces, the Atlas vertebra and small part of skull (?)
	Elephas antiquus (*Falc.*)	Two large teeth.*
Bison.	*Bison priscus* (?)	Part of horn core.
Ox.	*Bos primigenius* (*Bojanus.*)	Ultimate and penultimate molars.
Deer.	*Cervus sp.* ?	Humerus, etc.
Red Deer.	*Cervus elaphus* (*Linn.*)	Small part of skull with horn boss attached.
Horse.	*Equus caballus*	Distal end of left hind canon bone.

It cannot be said positively that the pieces of tusk, the atlas vertebra, and the small pieces of skull belong to the mammoth, but seeing that by far the greater majority of the teeth, etc., found, not only at Elloughton, but in similar gravels elsewhere, belong to this species, I have included them under this head.

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* Also the small one since found, already referred to.

The atlas vertebra is of especial interest, as it only rarely happens that this bone is found in gravel deposits.* It was in some twenty pieces when I got it, and not until these were put together could the specimen be identified. Though a large portion is missing, there is sufficient to shew that the original dimensions were about 10½ by 8 inches.

Regarding the gravels, Mr. Lamplugh states "I have an impression that these gravels may be the inland representatives of the Kelsey Hill beds."† The fauna of the lower gravel certainly has a similar *facies* to the fauna of the Kelsey Hill gravels, but the bones from the latter are generally well rounded and waterworn, often being like pebbles; this cannot be said of the Elloughton remains. At Elloughton, too, they are found in far greater numbers than at Kelsey Hill. The absence of marine shells and scarcity of far-travelled stones in the Mill Hill deposits, a fact noted by Mr. Lamplugh, is another point of difference. These latter gravels are also angular.

The same author has suggested that "the beds have accumulated in fresh water when the drainage of the lower Humber was encumbered and the water dammed back by ice";‡ but no additional evidence seems to be forthcoming either to support or contradict this view.

With regard to the Kelsey Hill beds, however, I endeavoured to explain in a paper read before this Society last year || that the chain of gravel mounds stretching across Holderness to Paull, and over into Lincolnshire, was a terminal moraine of the Norwegian Ice-sheet. In this moraine the Kelsey Hill, Burstwick, and other gravel pits are dug.

No doubt at one time the moraine would dam the drainage of the Humber, thus forming an extra-morainic lake§, but whether the

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* Dr. Henry Hicks has recently found one, together with other bones, in some gravels in London. See Quart. Journ. Geol. Soc., vol. xlviii., 1892, p. 453.

† Op. cit., p. 411. ‡ Op. cit., p. 410.

|| "On another section in the so-called Inter glacial Gravels of Holderness," Proc. Yorksh. Geol. & Polyt. Soc., vol. xiii., 1895, pp. 1-14.

§ See C. Lewis' "Glacial Geology of Great Britain and Ireland," 1894, which contains a chapter on "Extra-morainic Lakes of England," with map.

Elloughton gravels were deposited on the shores of this lake or not we connot at present say.

There is another interesting gravel pit (Mr. Prescott's) on the* low ground about a mile to the west of Elloughton. The gravel here is from 10 to 15 feet high, and is beautifully current-bedded, the most prominent beds dipping towards the south-east at an angle of about 45°. (See Fig. 2, Plate xxxviii.)

"The gravel is a drift gravel generally, *i.e.*, there is no filling in between the stones," and is composed principally of large flat pebbles of Millepore Limestone, with rounded edges. This limestone occurs *in situ* a few hundred yards to the north (the "Cockle" Pits), and a similar distance to the south, viz., at the foot of Mill Hill. It is also exposed on the Humber-bank adjacent. Chalk, Oolitic and Liassic pebbles and fossils are also found in the gravel.

So far as I am aware, no mammalian remains have been obtained from this gravel. In June, 1895, the quarrymen informed me that the core of a "cow's horn" had been picked out of some gravel which had been dug from a depth of 10 feet. Although I visited the place the same week, the horn could not be found, having been misplaced. I think, however, that this belonged to a comparatively speaking recent animal, and is of a date posterior to that of the formation of the gravel ; especially having regard to the fact that a human skeleton and ornaments of British workmanship have been found in the upper part of this section.†

This gravel differs from that on Mill Hill, in occasionally containing small pieces of wood. They are generally flat pieces, as though broken from a decayed tree, and are found at all depths. One bit, about five inches square and an inch thick, which, though greatly cracked, is very well preserved, was found lying on the top of a bed of sand at a depth of twelve feet.

With regard to the relative ages of the gravels just described, of course it is obvious enough that the bone-bearing gravel at the base of the section at Mill Hill, which consists of large blocks of

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* No doubt the same pit as is referred to in "Geology of parts of N. Lincs. and S. Yorks." (Geol. Survey Memoir), 1890, p. 146, par. 4.

† I am hoping to give an account of the objects of antiquarian interest, found in this and the Mill Hill Pit, in a future paper.

Coal-Measure sandstone, Millstone Grit, etc., and compact ferruginous sand, is older, probably much older, than the gravel forming the upper part of the section, which consists of material principally derived from the neighbouring Chalk, and contains no mammalian remains.

The gravel on the low ground, however, (Prescott's), is of a looser character than the upper gravel at Mill Hill, and is composed principally, not of Chalk, but of Millepore Oolite, outcrops of this rock occurring close by. Like the Mill Hill gravel, it contains a few fossils derived from the Lias, and also from the Chalk. The gannister, Millstone Grit, etc., which are found in the lower part of the Mill Hill section, are entirely absent here, though there is a huge boulder of fairly pure quartzite lying in the field which was once the quarry floor, and no doubt this boulder came from the gravel.

At present there seems nothing to indicate the relative ages of the gravels on the low ground and those on Mill Hill. Certainly the Lower Mill Hill gravel is the oldest, and I seem to be under the impression that the upper gravel at that place is of the same age, and consequently formed about the same time as that in Prescott's pit. Mr. Kendall, however, who has been over the ground since the paper was read,* thinks that the latter was formed subsequently to both the gravels on Mill Hill, and is, therefore, of a later date. Further evidence must be forthcoming, however, in order to settle this point.

There is (or was) a deposit at Bielbecks, which in many ways bears close resemblance to the Mill Hill series, not only in the composition and relative positions of the beds, but also in their respective contents.

Bielbecks† is the name of a farm situated between Market Weighton and North Cliff, and is about eight miles north-west of Elloughton. It lies between the 25 and 50 feet contour lines.

The beds were first exposed by the tenant of the farm, who dug out large quantities of material with which to marl his sandy soil. Mr. W. H. Dykes, of Hull, called the attention of Professor Phillips to the deposit in 1829, and a description of it by Messrs. Harcourt, Salmond, and Phillips appeared in the Philosophical Magazine for September of that year. Subsequently Mr. Harcourt gave the results of further investigations (six or seven hundred loads of marl having been removed),* and Phillips, in his "Geology of Yorkshire,"† gives a valuable summary of these two papers.

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* I have to thank Mr. Kendall for kindly permitting me to peruse the notes he made on this occasion, which contain a deal of information.

† Sometimes spelt Bealbecks, Bealsbeck, or Beele Beck.

The following is the succession of the deposits exposed at Bielbecks :—

	Feet.
(*a*) Yellow sand and gravel (the latter composed of chalk and sharp flints), with a few pebbles of quartz and sandstone, but containing "*no bones, shells, or vegetable remains*"‡	7½
(*b*) Grey marl, containing rolled pebbles of quartz, Mountain Limestone, and sandstone of the Carboniferous series, with chalk and flint. In this bed were found *numerous small fragments of tusk and teeth,* together with a few other remains of mammoth, and also a few bones of horse, rhinoceros, and deer	2½
(*c*) Black marl, containing minute pebbles of chalk, very few flints ; at the bottom, two or three pieces of fine-grained calcareous sandstone, similar specimens to which may be found in the adjacent red marl series ; no fragments derived from remote districts. Remains of elephant, horse, rhinoceros, wolf, and duck,‖ and also land and fresh-water shells were found in this layer	12½
Red marls, with no organic remains, form the base of the series	...
Total	22½

From this it will be seen that there is a striking similarity between the Mill Hill and Bielbecks deposits. The top gravel in each case is local, and contains no mammalian remains. The bed (*b*), like the lower gravel at Mill hill, contains boulders of Carboniferous sandstone, etc., and remains of mammoth, deer, and horse.

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* Phil. Mag., 1830.

† 3rd Edition, 1875, p. 12-19.

‡ The italics are mine.

‖ On page 168 of Phillips' "Yorkshire," in the "List of Mammalian Remains found in Pleistocene Deposits of Yorkshire," the cave lion (*Felis spelæà*) is mentioned as found "in Lacustrine clay, Bielbecks," and on page 273 the "fossil bear" (*Ursus arctus*) is also added, though it is not clear from which bed these specimens were obtained, probably from the lower one (*c*). The Bielbecks collection is now in the York Museum.

The limited extent of the Bielbecks beds is also interesting. Phillips says* "The basin of the red marl in which the lacustrine deposit is formed is very limited, only a few hundred yards long from east to west, and not so much from north to south ; the black ossiferous and shelly marl appears to be in one place only about 50 or 60 yards across. . . . About a quarter of a mile to the east is another marl deposit, covered by 5 or 6 feet of chalk gravel ; half a mile further in the same direction is another."

The bones, on the whole, are found in a similar condition, and represent a similar fauna in both localities. The remains of rhinoceros, lion, wolf, and duck, however, have not been found at Elloughton, neither have any shells been noticed at the latter place, though they were found in fair abundance in association with the bones at Bielbecks. It is possible they do occur at Mill Hill, however, but the small size of the exposure of the lower beds, coupled with the fact that the men would not take notice of the shells, will account for them not having been observed.

Phillips' remark that "Upon the whole, nothing can be more certain than that the bones in the black marl (at Bielbecks) were inhumed only a very small distance from the place where the animals died, that they had not been subject to the ravenous jaws of hyænas, nor been transported from any earlier deposit," also applies to the Mill Hill remains.†

List of Specimens exhibited when the paper was read :—

Four pieces of Tusk of Mammoth,	*Elephas primigenius.*
Two Teeth of Mammoth,	,,
Two Teeth of young Mammoth	,,
Atlas Vertebra of Mammoth	,,
Small piece of Skull of Mammoth	,,

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* Op. cit., p. 15.

† Phillips notices "a peculiar corrosion into little pits on one or two fragments" of bone ; a precisely similar feature is observable on a few bones, especially the flat pieces, from Elloughton.

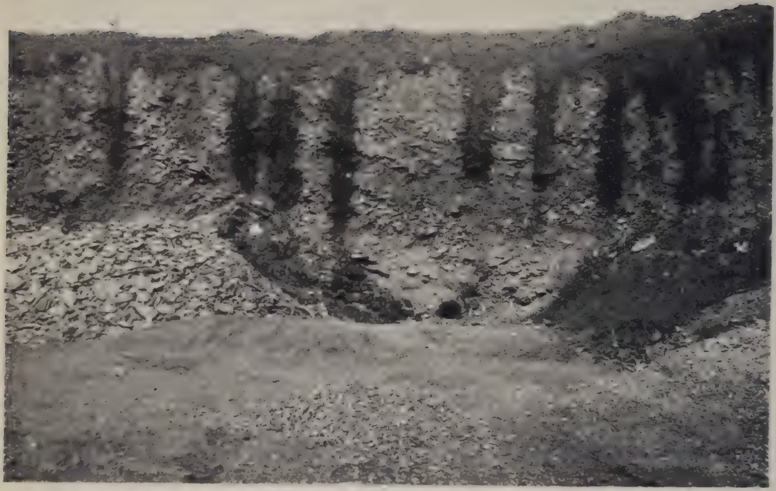


Fig 1.

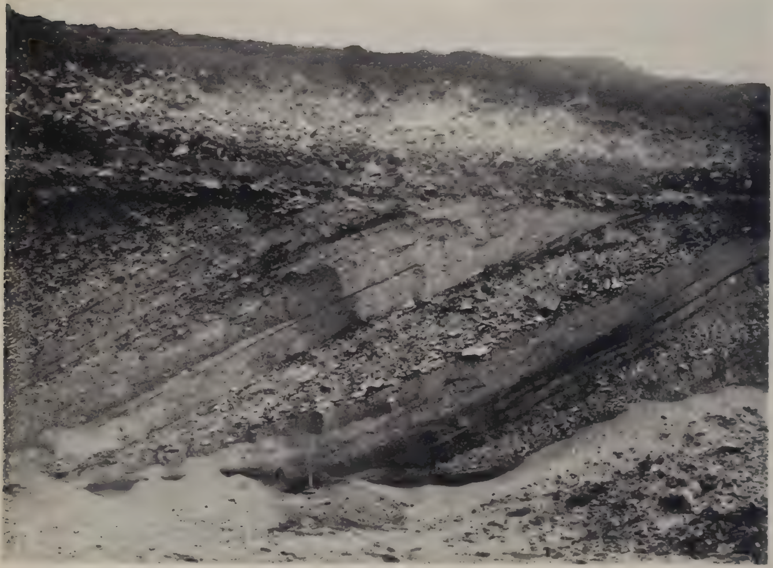


Fig. 2.

Prescott's Pit, Elloughton, East Yorkshire.

Proc. Yorks. Geol. & Polyt. Soc. Vol. XIII, Pl. XXXVIII.

Two large Teeth of *Elephas antiquus.*
Portion of Horn-core of Bison, *Bison priscus* (?)
Penultimate Molar of *Bos primigenius.*
Ultimate „ „
Humerus of Deer, *Cervus sp.?*
Right Horn Boss, with part of Skull, of Red Deer, *Cervus elaphus.*
Distal end of left hind Canon Bone of Horse, *Equus caballus.*
Stones with incrustations resembling serpulæ, etc.

EXPLANATION OF PLATE XXXVIII.

Fig. 1. PRESCOTT'S PIT.—Typical view of the pipes which occur in the gravel. Immediately under each pipe the gravel is partially cemented together. The loose nature of the gravel can be seen from the heap in the bottom left-hand corner.

Fig. 2. PRESCOTT'S PIT.—This excellent photograph shows very clearly the current-bedding in the gravels. Alternate beds of sand and gravel, dipping at an angle of 45°, are capped by a layer of fairly horizontal sand and gravel. Both gravels are precisely similar in composition.

I am indebted to my friend Mr. J. Hollingworth, M.R.C.S., for having kindly accompanied me to Brough and taken several photographs of the sections there exposed, from which the two accompanying this paper have been selected.

In Memoriam.

PROFESSOR A. H. GREEN, M.A. F.R.S., F.G.S.

Alexander Henry Green was born at Maidstone in 1832, the son of the Rev. T. S. Green, for many years head-master of the Ashby-de-la-Zouch Grammar School. He went from his father's school to Cambridge, and graduated as fourth Wrangler in 1855, when he was elected to a Fellowship in Gonville and Caius College. In 1861 he joined the Geological Survey, and after some months spent in Buckinghamshire and Oxfordshire was transferred to the Yorkshire and Derbyshire Coal-field, which was to prove the scene of his greatest labours. Here he got a deep and practical knowledge of Coal-measure geology, became expert in all the technical business of surveying, and acquired incidentally a sound knowledge of surface and glacial geology. He found opportunity also to examine with care parts of the Lake-country and Donegal. He was an early convert to the heresy now universally taught, that the surface of the ground owes its form mainly to the action of rain and rivers. It is amusing to recall that so late as 1866 the Geological Society refused to print Whitaker's paper on Sub-aerial Denudation, because it enforced this incredible doctrine.

In 1874 the Yorkshire College was founded, and Green was elected to the Professorship of Geology. His first scientific colleagues were Professors Rücker and Thorpe, now known to men of science all the world over. The first voluntary work which Green undertook as professor was the preparation of a new text-book of Geology, his Physical Geology, now in its third edition. This has become a classic ; it is full of knowledge, and everything is carefully thought out. The style is beautifully simple, and there is the charm, unusual in text-books, of a distinct personality. In preparation for this book Green studied petrology and mineralogy, which henceforth became favourite subjects with him. There are single paragraphs in the Physical Geology which cost weeks of hard work.

In 1878 the Geological Survey issued a volume of 800 pages on the Geology of the Yorkshire Coal-field. This was edited, and largely written, by Green. It is a store of well-sifted technical information on a subject of great practical importance. During his residence in Leeds Green visited Newfoundland and the Cape Colony

Photo. by MAULL-FOX, 187a, Piccadilly, London.

Yours truly

A. H. Green.

being commissioned to investigate the coal-bearing strata of those countries. He was elected to the Royal Society in 1886.

It was naturally expected that a geologist of Green's distinction, possessing just that knowledge which was immediately applicable to local industries, would have proved eminently successful as a Professor of Geology in the West Riding. Not only had he the knowledge and reputation which are essential, but he was a singularly clear and painstaking teacher. These expectations were not fulfilled. Hardly any students joined his geological classes during the fourteen years of his connection with the College, and he worked on under much discouragement till 1888, when he was appointed to succeed Sir Joseph Prestwich as Professor of Geology at Oxford.

In Oxford Green found plenty of congenial work. He arranged the neglected geological collections, investigated the geology of the Malvern Hills, and taught regularly. He was a favourite lecturer to occasional classes, and did much work as a consulting geologist. In 1890 he presided over the geological section of the British Association in Leeds.

His life, which had of late years been bright and prosperous, came to a sudden close on August 19th, 1896. He left behind him a widow (his second wife) and five children.

Green was throughout life a hard worker, very methodical and painstaking about everything which he undertook. He was an enthusiastic field-geologist, never in better spirits than when tramping home after a long day in the open country, though he was often laden with a weight of stones that would have made another man's heart fail. In character he was simple, honest, and fearless; very good-natured, especially towards children; a little hot when he thought himself or others to be treated unjustly. He liked simplicity in all things, never dressed the shop-window, never spoke or wrote for effect. If any exception is to be made to this last remark, it can only be that he took a harmless pleasure in decorating his grave writings with an occasional poetical motto. Poetry of all kinds he loved, as he also loved music and pictures. He had many friends, who now think of him as a man who played his part cheerfully and well, always putting his work first and his pleasures second.

L. C. MIALL.

In Memoriam.

THOMAS HICK, B.A., B.SC. (LOND.), A.L.S.

Born May 5th, 1840; Died July 31st, 1896.

Only a few months ago we chronicled the decease of a great Yorkshire Palæobotanist; to-day, alas! we deplore the death of another distinguished Botanist and Honorary Member of our Society through the death of Thomas Hick, B.A., B.Sc., A.L.S., who finished his course at the residence of his eldest son, Dr. Herbert Hick, at Laisterdyke, on the 31st of July last.

In early life our friend lost, through a severe accident, several fingers of his right hand. His indomitable spirit, however, struggled against his adverse surroundings, how successfully only those who have seen him, with deft skill, cutting beautiful sections of plants and stems by hand, can judge. Possibly this accident turned his attention from mechanical to literary and scientific pursuits, and, as often happens in life, what at first appeared an unqualified misfortune turned out a boon. Educated at The Royal Lancaster School, Leeds, Thomas Hick rose from the position of Scholar to the post of Master, and by private and strenuous study graduated in the first division as Bachelor of Arts and Science at the London University. At this time he was much engaged, teaching Mathematics, Botany, and Biology to the Science Students at Mechanics' Institutes at Leeds, Bradford, and elsewhere.

In 1876, a Science Master was wanted at Pannal College, Harrogate. The post was applied for, obtained, and held, with growing respect from the Principal and with the warm affection of the pupils, until 1886, when he was appointed Assistant Lecturer and Demonstrator in Botany at Owens College, Manchester. Like his chief, the late Professor W. C. Williamson, F.R.S., he was a Yorkshireman by birth and a gifted Palæobotanist, who added lustre to Lancashire, the county of his adoption. At Manchester he spent the next ten years of his life, crowding into that decade much brilliant original research; working hard almost to the last.

Yours Sincerely,
Thomas Hick

Proc. Yorksh. Geol. & Polyt. Soc., Vol. XIII., Part II.

He was an Honorary Member of the Yorkshire Geological and Polytechnic Society, elected thereto in recognition of his careful and accurate researches into the structure of the Carboniferous plants; he was for some time president of the Leeds Naturalists' Club and Scientific Association; also for one year President of the Harrogate Literary Society, and on leaving the town the members of this Society showed the high estimation in which he was held by making him a valuable presentation. The Yorkshire Naturalists' Union held him in great respect as a gifted member; as a member of the Manchester Literary and Philosophical Society he contributed several excellent papers to its Transactions. An interesting memoir of him appeared in the Owens College Union Magazine for October, 1896, and another one, from the pen of his old friend, Dr. F. Arnold Lees, in the "Naturalist" for March, 1897. In 1894 the Linnean Society showed appreciation of his contributions to Botanical Science by electing him to one of its twenty-five Associateships.

To the late Professor Huxley and to Mr. Thistleton Dyer he owed his training in biology; he was an ardent follower, one may indeed say a devoted disciple, of Huxley, whose character and method of work won his enthusiastic admiration. His knowledge of structural botany was extensive and profound, and he was well versed in current foreign (especially French and German) botanical literature. As a lecturer he was singularly clear, logical, and even fascinating; his visits to Halifax and Harrogate were always looked forward to with the greatest interest by a wide circle of admirers in these towns, where he commanded large and enthusiastic audiences. One of his last public lectures was given under the auspices of the Halifax Branch of the Sunday Lecture Society, and was exceedingly well received.

In Dr. F. Arnold Lees' appreciative memoir, published in the "Naturalist," very pleasing allusion is made to a small private Mutual Improvement Society which met fortnightly in Leeds, where such well known Yorkshire Naturalists as Hick, Davis, Lees, Todd, Abbott, and Watson, discussed science and philosophy together. In Halifax too he was a welcome visitor to a similar Society where the late J. W. Davis, the late Geo. Brook, W. P. Sladen, C. P. Hobkirk, Jno. Stubbins, W. Townend, myself and some others, met for scientific improvement, and where 'as iron sharpeneth iron' we sharpened our wits in the investigation of scientific problems for the love of truth. Hick wrote reviews on scientific books, many of the best appearing in the "Leeds Mercury." He thus brought a wide range of knowledge, a critical faculty, and a sound judgment which was highly esteemed in our little circle. Through the kindness of Messrs. Binns, Spencer, Lomax, and others grand opportunities were afforded him of studying the fossil flora from the Coal-beds of the Hard Bed of Yorkshire, and the upper foot mine of Lancashire. How nobly these opportunities were used the list of able memoirs quoted at the conclusion of this paper bear witness.

Dr. F. Arnold Lees writes that "Hick's first original paper was 'On an overlooked point in the Morphology of Ficaria verna.' It showed an unusual gift of exact observation, and foreshadowed the brilliancy of later papers in the 'Journal of Botany' on the Continuity of Protoplasm in the tissues of certain Marine Algæ. He was too careful and self-critical a worker to produce voluminously."

Our friend's scientific work may be said broadly to have been mainly Botanical (with the exception of three joint Palæobotanical papers) from 1878 to 1890.

In 1891, he commenced a series of singularly lucid papers on the Structure of the Carboniferous Plants, in which he dealt with "The present state of our knowledge of the Yorkshire Calamitæ," "Xenophyton," "Calamostachys Binneyana," "The Fruits of Calamites," "The Stems of Calamites," "Kaloxylon Hookeri and Lyginodendron Oldhamium," "Leaves of Calamites" (a luminous paper), "Rhachiopteris cylindrica," &c.

If Hick had been more of an egoist, if he had cared to push himself, he would probably have been more widely known, and, in a sense, have been more successful; but he cared most to do good work that would last. He was accurate, thorough, clear, logical in all he wrote and taught. Doubtless, had his life been spared, he would soon have ranked with the foremost Palæobotanists of Europe.

His private character was genial, generous, transparent. He was an able controversialist, and it needed a clear-headed man to hold his own with him in argument. He always laid great stress on the difference between knowing a thing and knowing *about* it; he never played pranks with his reason; he loved and followed Truth for its own sake.

In the summer of 1896, we noticed with anxiety that our friend's health was declining; the fine intellect worked almost to the last; but a painful disease seized him and quickly, though borne with manly courage and fortitude, vanquished his noble soul. He left to mourn his loss a devoted wife and two sons, as well as a large circle of sorrowing friends.

The Owens College Museum is enriched with his choice collection of micro-preparations of Fossil Carboniferous Plants, largely illustrative of his own special researches. This collection was purchased by private subscription, and forms a fitting monument of one who was perhaps the most promising rising Palæobotanist of his day.

WM. CASH.

SCIENTIFIC PAPERS, &c., BY THOMAS HICK, B.A., B.Sc., A.L.S.

1878. 1 "The Sexual Reproduction of Fungi," read before the Leeds Naturalists' Club, 17th Sept., 1878. "The Naturalist," Jan. and Feb., 1879.

,, 2 "A Contribution to the Flora of the Lower Coal Measures of the Parish of Halifax, Yorkshire," by Wm. Cash and Thomas Hick. Yorksh. Geol. and Polytech. Soc. Read 28th Oct., 1878.

1879. 3 "On Fossil Fungi from the Lower Coal Measures of Halifax, and Notes on Traquaria," by Wm. Cash and Thomas Hick. Yorksh. Geol. and Polytech. Soc.

1882. 4 "On the Designation of certain functions of Plants." "The Naturalist" March, 1882.

,, 5 "On the Caulotaxis of British Geraniums." "Journal of Botany," October, 1882.

1883. 6 "Notes on Ranunculus ficaria, L." "Journal of Botany," July, 1883.

1884. 7 "On Protoplasmic Continuity in the Florideæ." "Journal of Botany," Feb., 1884.

1885. 8 "Protoplasmic Continuity in the Fucaceæ." "Journal of Botany," April, 1885.

,, 9 "Strasburger's New Investigations on the Process of Fertilisation in Phanerogams." "The Naturalist," Feb., March, April, and July, 1885.

,, 10 "On the Caulotaxis of British Fumariaceæ." "Journal of Botany," Sept., 1885.

,, 11 "Protoplasmic Continuity of the Fucaceæ." "Journal of Botany," Dec., 1885.

,, 12 "Strasburger on Foreign Pollination." "The Naturalist," Dec., 1885.

1889. 13 "The Mechanical Tissues of Plants." "Transactions and Annual Report of the Manchester Microscopical Society," 1889.

,, 14 "The Structure and Afflnities of Lepidodendrons," by Thos. Hick and Wm. Cash. Proc. Yorks. Geol. and Polytech. Soc., vol. xi., pt. ii., pp. 316-332, 1889.

1890. 15 "Ludvig Klein on The Genus Volvox." "The Naturalist," March, 1890.

1891. 16 "Baillon's Medical Botany." "The Westminster Review," Feb., 1891, pp. 158-164.

,, 17 "On the Present State of our Knowledge of the Yorkshire Calamitæ." Proc. Yorks. Geol. and Polytech. Soc., vol. xii., pt. i., pp. 1-8, 1891.

,, 18 "Volvox in Yorkshire." "The Naturalist," June, 1891.

,, 19 "On a New Fossil Plant from the Lower Coal Measures." (Read 19th November, 1891.) "Linnean Society's Journal—Botany," vol. xxix., pp. 86-102.

,, 20 "Volvox." Transactions and Annual Report of the Manchester Microscopical Society, 1891.

1893. 21 "Modern Views of the Plant Cell." Transactions and Annual Report of the Manchester Microscopical Society, 1893.

,, 22 "On a New Sporiferous Spike from the Lancashire Coal Measures," by Thos. Hick and Jas. Lomax. (Received

31st Oct., 1893.) Memoirs and Proc. Manchester Lit. and Phil. Soc., vol. viii., ser. iv. Session 1893-4.

1893. 23 “Calamostachys Binneyana, Schmp.” Proc. Yorks. Geol. and Polytech. Soc., vol. xii., pt. iv., pp. 279-293, 1893.

,, 24 “The Fruit Spike of Calamites: A Chapter from the History of Fossil Botany.” “Natural Science,” vol. ii., No. 15, May, 1893.

1894. 25 “On the Primary Structure of the Stem of Calamites.” (Received 20th Feb., 1894.) Memoirs and Proc. Manchester Lit. and Phil. Soc., vol. viii., ser. iv., pp. 158-170. Session 1893-4.

,, 26 “On Kaloxylon Hookeri, Will., and Lyginodendron Oldhamium, Will.” (Received 31st May, 1894.) Vol. ix., ser. iv., Session 1894-1895, pp. 109-117. Manchester, 1895.

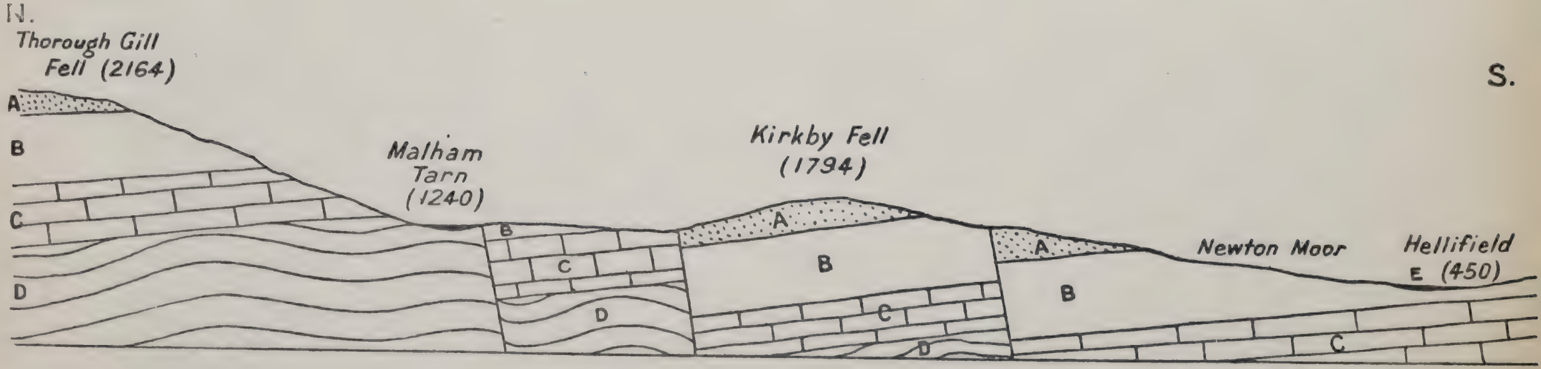
1895. 27 “On Some of the Characteristics of the Plants of the Coal Measures.” (19th Jan., 1895.) Transactions and Annual Report of the Manchester Microscopical Society, 1894.

,, 28 “On the Structure of the Leaves of Calamites.” (Received 30th April, 1895.) Memoirs and Proc. Manchester Lit. and Phil. Soc., vol. ix., ser. iv., Session 1894-5, pp. 179-190. Manchester, 1895.

,, 29 “On some recent advances in British Palæobotany.” (Received and Read 13th Nov., 1895.) Proc. Yorksh. Geol. and Polytech. Soc., vol. xiii., pt. i., pp. 43-57., 1895.

,, 30 “On a Sporangiferous Spike from the Middle Coal Measures near Rochdale.” (Received December 10th, 1895.) Memoirs and Proc. Manchester Lit. and Phil. Soc., vol. x., ser. 4. Session 1895-6, pp. 73-79, Manchester, 1896.

1896. 31 “On Rhachiopteris cylindrica, Will.” Posthumous. (Received and Read 6th October, 1896.) Memoirs and Proc. Manchester Lit. and Phil. Soc.,” vol. xi., pt. i., Session 1896-7, Manchester, 1896.



General Section across Craven Faults.

A. *Millstone Grit.*
B. *Yoredale Beds.*
C. *Carboniferous Limestone.*
D. *Silurian Beds.*
E. *Alluvium.*

NOTES ON THE GEOLOGY OF MALHAM AND SETTLE.

BY W. LOWER CARTER, M.A., F.G.S.

The Spring General Meeting, May 8th, 1896, was held at Malham, under the presidency of Mr. Walter Morrison, M.P., and the area under investigation on May 8th and 9th included Gordale, the Malham Dry Valley, the Victoria Cave, and other interesting geological features of the district. The following notes were originally compiled for the use of Members during the Excursion, and form a record of the work done on that occasion.

The party travelled to Bell Busk Station, where they were met by the leader, Mr. Walter Morrison, M.P., and proceeded by waggonettes to Malham. The road from Bell Busk follows the course of the River Aire, by Aire-Head Springs, to Malham, passing over beds of Carboniferous Limestone and Yoredale rocks.

About one mile and a half from Bell Busk, a conspicuous white house on the east of the Aire, in the hamlet of Calton, marks the site of the house of General Lambert, who owned a large estate in the parish. After passing Airton, Kirkby Malham is reached, where a short halt was made to inspect the church, which is a noble specimen of North Country Perpendicular. The pillars have Saints' niches on their western faces, said by Whitaker to characterize churches built by the great Craven Family of the Tempests. It contains a very ancient, curious, and probably unique font, and some monuments of the Lambert Family and of an unknown prior. The Register has entries of marriages celebrated by Oliver Cromwell; in one case the bridegroom was a certain Martin Knowles, who lived at Middle House, about a mile north-east of Malham Tarn. This house is almost the highest house in England, being 1,500 feet above sea-level, or 24 feet higher than the house in the Kirkstone Pass. From the hill between Kirkby Malham and Malham, Malham Cove, the entrance to Gordale, and the road leading to Malham Tarn, are conspicuous.

At Malham the huge scars of Mountain Limestone are reached, which form a magnificent barrier across the end of the valley, rising at Malham Cove to the height of 285 feet, and at Gordale to 300 feet. These scars are caused by the Mid-Craven Fault, which has brought down the sandstones of the Millstone Grit against the compact Mountain Limestone.

Leaving the conveyances at Malham, the party followed the route to Gordale, which is a magnificent illustration of a limestone gorge. Gordale is essentially a water-worn ravine, with a rapid stream wearing down the soluble limestone. The vertical sides of the narrow gorge below the fall suggest that an underground stream formed first of all a cavern, which was converted into an open ravine by the falling in of the roof. As examples of depositions may be noticed the laminated masses of travertine, where the water is subject to rapid evaporation, at Gordale Scar and in Janet's Cove. The stones in the limestone streams, it will be noticed, are encrusted with round masses, the work of an *alga (Rivularia calcarea)*, which abstracts the carbonic acid for its nutriment, thus causing the carbonate of lime to be thrown down. The northern branch of the Craven Fault is exposed in Gordale Beck, and is filled by a wide vein of breccia. This fault brings down the solid limestone of Gordale against the Upper Silurian Grits of the Coniston Series. The base of the Mountain Limestone north of the fault, which consists of a kind of sandstone containing Silurian pebbles, was crossed on the way to the Tarn.

Malham Tarn is a natural sheet of water about half a mile square, surrounded on three sides by peaty moor or bog, and on the north shut in by fine limestone scars. This district is the habitat of many rare plants, the search for which formed an interesting variety from the more strictly geological work. Malham Tarn stands 1,240 feet above sea-level, and covers about 160 acres. It fills a shallow hollow in the Silurian rocks, its greatest depth being fourteen feet, five feet being due to an embankment at the southern end, constructed first by Lord Ribblesdale, and afterwards rebuilt. Some mounds of sub-angular gravels lie east and south of the Tarn, which may be of glacial origin.

The return journey was devoted to the examination of the Malham Dry Valley, which is probably unique in England in the perfection of its preservation. After running for half a mile southwards, the stream from Malham Tarn sinks into the limestone by two or three large openings filled with limestone blocks. Formerly it must have followed the course of the Dry Valley, and have precipitated itself over the sheer cliffs at Malham Cove, forming a waterfall of noble proportions. Another stream, rising in the neighbourhood of Capon Hall, flows over the expanse of weathered Mountain Limestone called the "Streets," and disappears in a fissure near the old smelting mill. That the course of these upland waters has not always been subterranean we have ample proof, not only in the geological structure of the district, but also on the testimony of eyewitnesses who saw the stream resume its old channel under conditions of exceptional rainfall.

Hartley, the Malham Schoolmaster, writing in 1786 says :— "From the apex of this Cove, after what is in this part of the country called a Rugg, or a succession of rainy and tempestuous weather, when the water-sink at the southern extremity of the Tarn is unable to receive the overflux of the Lake, there falls a large and heavy torrent, making a more grand and magnificent cascade than imagination can form any idea of. This vast and precipitate cascade, so generally enquired after, and so seldom seen by travellers in the summer months, hath been so much admired as to leave it equally subject of wonder and concern, that the inlets of the stream, which might easily be done, have not been stopped, and this lofty and imperious cataract thereby rendered a perpetual object of gratification and astonishment."

Howson, in his "Curiosities of Craven" (1850), says :—"Twice within the last forty years the *swollen waters* of the Tarn have made their way over the Cove, but the torrent was dispersed in one vast cloud of spray before it reached the bottom. Its density and the magnificent sight may be imagined from the fact that the spectators could not approach within a hundred yards of the foot of the rock without being drenched through."

Which way does the Aire run now ? and to which stream belongs the honour of being its source ? These are questions which have aroused much controversy, and to the solution of which a considerable amount of ingenuity and attention have been devoted. Whitaker, in his "History of Craven" (1805), says—"Speaking in general terms, the lake may fairly be considered as the source of the Aire ;

but as its outlet quickly sinks into the ground and is lost, and as several streams which appear below contend for the honour of the connection, it still remains a matter of some uncertainty to which of them the preference is to be given. The inhabitants of Malham plead that the waters of the Tarn actually appear again in two most abundant and beautiful springs about a quarter of a mile below the village, and nearly three miles from the place of immersion. This opinion seems most probable. But from the foot of the Cove, and almost a mile nearer to the Tarn, a copious stream breaks out, which has undoubtedly the second claim. Yet it is well known that a collection of springs rising in the Black Hills, the Hensetts and Withes, is swallowed up in a field called the Streets; and from the turbid quality of the water, very unlike that of the Tarn, there is little doubt that, after a subterranean course of more than two miles, this is the stream which here emerges again. Thirdly, the Airton water, from which the village derives its name, seems precluded by its distance from any reasonable pretensions. Fourthly, Gordale water, which springs in the Great Close, and of which the whole course may be traced, can have no other claim than that of a collateral feeder."

A series of experiments made some years ago to determine which was the true outlet of the water from Malham Tarn, proved conclusively that when the sluice-gates of the Tarn are closed, and after an interval the water is let down, that the water first reappears at Aire-head Springs, between Malham and Kirkby Malham, and only after a longer interval is the outlet at the foot of the Cove affected.

The second day's route traversed the fine series of scars which mark the lines of the Craven Faults between Malham and Settle. Shortly after leaving the Buck Inn, on the bridle-road to Settle, some disused calamine pits were passed. The walls hereabouts have yielded many fossils, including trilobites. A visit was paid to a curious spring in the limestone called "Clattering Sykes," which throws up fossils.

Thence the route taken was along the line of the Craven Fault and up Attermere scars to the Victoria Cave, so famous for its yield of the remains of hyæna, bear, and pre-historic man. This cave, the largest of many caves in these scars, was discovered by Mr. Joseph Jackson, of Settle, on the day of Her Majesty's accession to the throne, and hence was christened by that active investigator "Victoria Cave." The Victoria Cave is excavated in the face of Kingscar, a vertical cliff of Mountain Limestone, 200 feet high, and 900 feet above the Ribble, which flows through the valley beneath, and 1,450 feet above sea-level. The cave consists of two main compartments, each exceeding 100 feet in length, and possesses several entrances. When discovered, the outer cave was found to be filled to within two or three feet of the roof with solid, tenacious clay, which formed a barrier to its examination, but in the inner chamber various human relics were unearthed. Since 1870 the cave has been systematically investigated by a Committee of the British Association, with most important results.

By the removal of several yards of talus, the result of the weathering of the cliffs, the entrance to the cave was cleared down to the floor. A trench was then excavated through the cave deposits, and disclosed evidence of a series of successive occupations by man and animals during pre-historic times. A thin dark line along the side of the trench marked the most recent occupation. Near the entrance it consisted of about two feet of charcoal, bones, etc., forming the ancient hearths of men who had used the cave for a home ; the bones being remains of animals such as still live in Britain—the Celtic short-horned ox, the goat, pig, horse and dog, with the occasional remains of stag, badger and fox, and the domestic fowl. As to the date of these latest cave-dwellers, the presence of remains of the domestic fowl, introduced into this country by the Romans, form a chronological limit in one direction, and the abundant use of the short-horned ox for food gives us another limiting date. For this species of ox, which is now confined to the mountains of Wales and Scotland, was the only breed of oxen used by the inhabitants of the Brit-Welsh kingdom of Elmete, which extended from Leeds to Settle, and which was devastated by the English in 615, when the men and oxen of that period were driven westward by the ancestors of the present Yorkshire dalesmen, and had to defend themselves in the fastnesses of Wales. These facts combined show that the cave was last inhabited by the Brit-Welsh people of the fifth and sixth centuries.

At a depth of six feet below this layer another bed of charcoal and ashes was found, in which were Roman coins, implements, and ornaments, together with implements made of ground and polished bone and flint. Bone harpoons, chipped flint tools fastened into bone handles, arrow heads, and polished stone celts, mark the Neolithic stage of culture. These people differed very essentially from those whose remains were found in the upper layer. The domestic animals by which they were accompanied had never roamed wild in Britain. They had been domesticated in Asia, and from that continent these men had pushed westward, and were, in all probability, closely allied to the Basque tribes occupying the Iberian peninsula, and the north of the Pyrenees, at the dawn of history. Entering the cave, this layer was found to pass insensibly into the cave-earth containing the bones of the brown bear, grizzly bear, cave bear, reindeer, and other animals belonging to northern regions.

Twenty feet below the Neolithic layer a bed of blue till was found, filled with ice-scratched boulders of limestone, Silurian grit, and other far-travelled rocks. The rock striæ in the adjoining cliffs showed the direction of the ice-sheet to have been from Stainforth to Long Preston, by way of Attermere Tarn, filling the ravine in front of the cave, and blocking the entrance to it by its lateral moraine.

These products of the ice-sheet rested upon the upturned edges of a layer of lower cave-earth, dipping inwards, enclosing a bone-bed of animals, none of which now lives in Britian, among others the spotted hyæna, hippopotamus, rhinoceros, and elephant, the last two of species now extinct, and all indicating a tropical climate. On further excavation, the remains of wolf were found at a depth of about twenty-six feet below the Neolithic layer, which proved its existence in England at a much earlier period than previously had been supposed.

A visit was paid to the Museum at the Giggleswick Grammar School, in which are deposited the many interesting remains that have been discovered in the deposits of the Victoria Cave. These relics comprise both historical and fossil remains, proving the occupation of the cave at intervals by early English, Roman, and Celtic peoples, and further back still by the pre-historic men of the Neolithic and Palæolithic ages.

Amongst the objects illustrating the historic period are specimens of Samian and Roman pottery, silver coins of Trajan, bronze coins of Tetritus, Galienus, and Constantine II., and some barbarous imitations of Roman coins, of Celtic workmanship. A number of objects in bone, perforated bone studs, needles, a beautifully ornamented spoon-shaped bone fibula, and a flat bronze pin with bicuspid end for graving the bone ornaments. Spindle whorls made from Silurian pebbles, from the perforated femur of the small ox, and even from fragments of pottery, are to be seen. Among the articles of personal adornment exhibited in the Museum are bronze brooches inlaid with coloured enamels, a harp-shaped bronze fibula, dragonesque bronze brooches enamelled, a spirally coiled gilt-bronze brooch, bronze and silver rings, and beads of transparent and coloured glass.

Among the objects exhumed from the Neolithic layer there are for exhibition rude flint flakes, polished celts, bone bead, and a barbed bone harpoon for spearing fish. Fine specimens of reindeer antler, and a massive skull of grizzly bear are also to be seen.

From the Palæolithic layer there are teeth of an extinct elephant, bones of the bison, urus, hippopotamus bearing marks of the hyæna's teeth, and part of a rhinoceros' skull.

The Museum was thrown open for the inspection of the members, by the kindness of the Head Master, and the specimens were described by the Curator.

In the compilation of these Notes for use of the party, I gratefully acknowledge the important information kindly furnished by Mr. Walter Morrisson, M.P., and the late Mr. Thos. Tate, F.G.S.

NOTES ON THE COAST BETWEEN REDCAR AND SCARBOROUGH.

BY C. FOX-STRANGWAYS, F.G.S., OF THE GEOLOGICAL SURVEY.

[*Written for the Excursion Circular of the Whitby Meeting, July 31st and August 1st, 1896.*]

The northern part of the Yorkshire Coast which the Society propose visiting this summer comprises a series of lofty cliff sections, giving magnificent exposures of nearly the whole of the Lias, and a considerable portion of the Lower Oolite. Commencing at the northern end we first meet with the thin limestones and oyster bands that are seen on the shore opposite Redcar on the south side of the estuary of the Tees, and which constitute the zones of *Am. angulatus* and *Am. Bucklandi.*

The Rhætic beds and the lowest beds of the Lias (zone of *Am. planorbis*) are not exposed here, but have been met with in artificial sections a short distance inland. Proceeding southwards from Redcar the cliff is occupied entirely by glacial deposits till we reach Saltburn, a distance of four miles. At this point the northern escarpment of the Lias strikes the coast, the whole of the Middle Lias and a large part of the Lower Lias being exposed in the precipitous face of Huntcliff.

On the shore here the *Jamesoni*-beds form extensive scars at low water, while in the cliffs above we have the full thickness of the *capricornus* and *margaritatus*-beds, the *spinatus*-beds containing the Main Seam of Ironstone outcropping just along the edge of the cliff. This section is again repeated at Hummersea where the beds are more accessible, the junction between the Lower and Middle Lias being close to high-water mark. In the magnificent cliffs of Boulby, 600 feet in height, just south of this, there is a complete section from the lower part of the Oolites to the *Jamesoni*-beds. A great part of this, from the precipitous nature of the cliffs, is inaccessible, but the higher portion may be reached in the old alum works. These alum works are well worth a visit as showing the large extent of this industry in former times, and as being the locality from which many of the large saurians were obtained. At Staithes the sandy beds of the Middle Lias reach the shore and are regularly succeeded by the Ironstone Series and the lower portion of the Upper Lias. The lower beds here are very rich in starfish, while the beds above, which include the zones of *margaritatus*, *spinatus*, *annulatus*, and *serpentinus*, from their gradually declining to the shore, are very favourably situated for examination.

At Rosedale Wyke a shaft has been sunk to the ironstone, which is here worked below sea-level. South of this a small dislocation repeats some of the beds, so that after crossing the picturesque bay of Runswick we get the Ironstone Series again exposed at Kettleness Point. Here at one time the ironstone was dug on the shore, and sent away by ship to the northern furnaces, a large amount of it having been removed. The coast between Kettleness and Sandsend exhibits a good section of the three divisions of the Upper Lais (the *annulatus*, *serpentinus*, and the *communis*-beds), but from the sea washing the base of the cliff it is rather a dangerous one to explore. The old jet holes along here form a series of caverns which have a very weird effect.

At Sandsend there are large alum works, which are interesting as being the last that were in operation. The cement-stones in the upper part of the Lias at this place were also worked for making Roman Cement. Between this point and Whitby, a distance of nearly three miles, the cliffs are mostly occupied by Boulder Clay till we get close to the town, when the sandstones of the Inferior Oolite begin to appear.

At Whitby Harbour there is a fault having a throw down to the west of 200 feet, so that the Upper Lias again appears on the east side capped by the lower part of the Inferior Oolite. This is one of the most favourite places for collecting the ammonites and other fossils of the Upper Lias ; but the scars have been so frequently examined by collectors that not much of any value can be obtained at the present time.

Beyond Saltwick the coast becomes inaccessible for some distance, but at Hawsker, where the Middle Lias again comes up, the several divisions of the Middle and Lower Lias may be followed to Robin

Hood's Bay. The *spinatus* and *margaritatus*-beds are well seen at Hawsker Bottoms, and it is interesting to observe the change in character which has taken place between here and the sections further north. The great ironstone seams of Cleveland have nearly disappeared, and are only represented by narrow bands which are difficult to correlate with these well known beds.

In Robin Hood's Bay the strata are thrown up by an anticlinal axis, and the lower beds of the Lias are again exposed in the extensive scars which may be examined at low water. These scars are composed of the several zones of the Lower Lias, which, from the quaquaversal dip of the beds, form a series of semicircular bands round the centre of the bay. The lowest beds of the Lias (the zone of *Am. planorbis*) are not seen here, but their presence is proved by blocks containing the characteristic ammonite being occasionally washed up by the waves. The *Bucklandi*-beds occupy the centre of the bay, being succeeded by the *oxynotus*-beds which form a semicircle partly covered by sand between Bay Town and Peak; these in their turn are covered by the *Jamesoni*-beds at either end of the bay, above which the *capricornus*-beds rise in the cliff. At low water these several zones may be followed by the eye for some distance.

On the south side of the Bay the Peak cliffs rise to an altitude of over 600 feet, and exhibit a magnificent section of the lower part of the Inferior Oolite and of the upper part of the Lias. The chief point of interest here is the large fault having a throw of about 200 feet, which has brought the sandy beds of the Middle Lias against the Inferior Oolite, and which is clearly seen in the cliff where the footpath descends at this spot.

A short distance further south we come to the little indentation of Blea Wyke, where the base of the Oolite reaches the shore, and where the unique section of the sandy passage beds between that formation and the Lias occurs. The Blea Wyke Beds have been referred by some authors to the Lias, by others to the Inferior Oolite; they have a thickness of about 50 feet or rather more, and this is the only place they are known for certain to occur, their presence inland being doubtful. The Dogger, the marine bed at the base of the Inferior Oolite, is here a ferruginous sandstone with a peculiar diagonal system of joints; it is 30 feet or more in thickness, and in certain parts contains great quantities of fossils, especially gasteropoda.

The Staintondale Cliffs to the south of this are composed entirely of the Estuarine Series of the Lower Oolite, with the three marine divisions of the Eller Beck Bed, the Millepore Bed, and the Grey Limestone Series. The Middle Estuarine Series between the Grey Limestone and the Millepore Bed is particularly rich in plant remains; while the sandstones below this also contain a good number, more especially *Equisetites* and the roots of plants in a vertical position. It is in these beds that the Oolite coals occur which have been worked to some extent inland, but they are not of any thickness on the coast.

The marine bands of the Millepore Bed and the Grey Limestone come to the shore on either side of Cloughton Wyke, where they form conspicuous reefs which can be examined at low water. Between this point and Scarborough the coast is formed by the sandstones of the Upper Estuarine Series; the cliffs, being mostly composed of glacial gravel, are not of very much interest or variety.

SECRETARY'S REPORT.

The work of the Society during 1896 has been exceptionally successful, the interest of the Meetings having been maintained at a high level by a series of interesting communications on Yorkshire Geology, whilst the exceptionally fine weather made the Field Excursions occasions of delightful holiday as well as opportunities for interesting Scientific investigations.

The Spring General Meeting and Field Excursion was held at Malham, in Craven, on May 8th and 9th, under the presidency and leadership of Mr. Walter Morrison, M.P., one of our Vice-Presidents. There was a good muster of the members at Bell Busk Station on Friday morning, May 8th, where they were met by Mr. Walter Morrison, and conveyed by waggonette to Malham. At Kirkby Malham a halt was made to view the interesting Church and its ancient registers, and the Yoredale beds exposed in the bed of Kirk Gill Beck were examined. Alighting at Malham, the party proceeded on foot across the fields to Gordale, and ascended the steep path up the magnificent limestone gorge. The way was then taken across the moorlands to see an exposure of Silurian beds on the north side of the Craven Faults, and thence a rapid march brought the party to Tarn House, where they were most hospitably entertained by Mr. Morrison. After luncheon the party walked round Malham Tarn to the Watersinks, and thence down the Dry Valley to the Cove, the leisurely inspection of this interesting relic of the ancient denuding work of the Aire being much appreciated. The members dined together at the Buck Hotel, Malham, and subsequently the General Meeting was held.

The Field Excursion was continued on Saturday, May 9th, an early start being made, under Mr. Morrison's guidance, for the moors north of Malham, where a visit was paid to an interesting spring called "Clattering Sykes," which throws out fossils. The chief springs were dry, but the fossil hunters found congenial work in securing specimens of the crinoid plates and other small fossils which were scattered about in abundance. The party then proceeded under the great limestone scars to Stockdale Farm, a detour being made to examine a large vein of white quartz which marks the line of the mid-Craven fault. Attermere Scars were then climbed, and a visit paid to the renowned Victoria Cave in the face of Kingscar. After an enthusiastic vote of thanks had been passed to our leader for his extremely courteous and efficient conduct of the party, the shortest way was taken to Settle, where a visit was paid to the Giggleswick Museum, and its fine collection of relics of the various occupations of the Victoria Cave were inspected with much interest. Dinner at the Lion Hotel, Settle, under the presidency of the Hon. Secretary, terminated a most successful Meeting, noteworthy for perfect weather, genial leadership, and good comradeship all round.

The Summer Meeting and Field Excursion was held at Whitby, on July 31st and August 1st, for the examination of the Coast Sections between Blea Wyke and Whitby. The Field Excursions were under the efficient leadership of Messrs. P. F. Kendall, F.G.S., W. Y. Veitch, M.R.C.S., and the Rev. John Hawell, M.A. On Friday, July 31st, the members assembled at Robin Hood's Bay and made their way along the shore to Hawsker Bottoms, noticing the fine section of the Lower and Middle Lias beds exposed in the cliffs. At Hawsker the cliffs were ascended by a steep path, and most of the members walked back to Whitby.

The second day's route was from Blea Wyke to Bay Town. The train was taken to Staintondale Station, and the cliffs were gained by a cross-country path. A steep descent brought the party to Beast Cliff, the result of an old landslip of large dimensions. Here a most unusual scene, for the seaside, met the eye. Thick brushwood, fern, and heather, forming a jungle through which progress was a matter of difficulty, amid which were pools containing water lilies and bulrushes of two kinds. A way down the cliffs to the shore was found near Blea Wyke, and the rough mass of blocks that forms the beach there was slowly traversed. Good finds of characteristic fossils were bagged from the Dogger Beds at Blea Wyke and the Alum Shale at Peak. After examining the fault at Peak, Robin Hood's Bay was crossed, large numbers of Shap and other glacier-carried boulders being noticed on the shore, and the train was taken back to Whitby. The members dined together at the Crown Hotel, and after dinner the General Meeting was held under the presidency of Mr. Percy F. Kendall, F.G.S. During the Meeting sympathetic reference was made to Mr. Thos. Hick, A.L.S., B.Sc., news of whose sudden death had been received, and a resolution of sympathy and condolence with his widow and family was passed.

In continuation of this Field Excursion the members joined the Yorkshire Naturalists' Union at Staithes, on Monday, August 23rd. The train was taken to Easington and a visit paid to Boulby Alum Pit. After examining the section and obtaining specimens of the characteristic fossils a return was made by train to Hinderwell. Thence the shore was reached by way of Runswick and the cliff section followed to Staithes. Numerous fossils were obtained, the best "find" being a slab of Ichthyosaurus remains which was secured by the Rev. J. Hawell. The members attended the General Meeting of the Yorkshire Naturalists' Union at Staithes, and then returned to Whitby. After dinner the General Meeting was resumed for the consideration of the papers read on Saturday evening, and a lively discussion ensued. A visit was paid by several of the members on Tuesday morning to Saltwick Nab, an excursion which resulted in the fortunate find of some gasteropods new to that locality, the aptychi of Ammonites, and other fossils. The members in separating were able to congratulate one another on a most successful and instructive Meeting.

During the year the Library of the Society has been transferred to, and suitably housed at, the Philosophical Hall, Leeds. The books consist chiefly of the Memoirs of the United States Geological Survey and the publications of Scientific Societies sent in exchange for our Proceedings. The best thanks of the Society are due to Mr. Henry Crowther for the trouble he has so kindly taken in the suitable arrangement of these books in the cases assigned to them by the kindness of the Council of the Leeds Philosophical and Literary Society.

One piece of important original work in connection with Yorkshire Geology has been commenced by Mr. Kendall, viz., a detailed investigation of the glacial deposits on the eastern side of the Pennine Chain. The facts in his possession had been growing rapidly, and the time seemed ripe for attempting the thorough elucidation of the many interesting glacial phenomena. Your Council felt that it was their duty to assist in such an interesting and important series of investigations, and, as the expense entailed would be considerable, they have resolved to provide Mr. Kendall with 6-inch contour Maps for the purpose of this detailed survey, the expenditure not to exceed £6, on the understanding that the results of the survey shall be communicated, in the first instance, to this Society, and that the Maps, when completed, shall be deposited in our Library.

The Editors of the Proceeding much regret that, owing to unforeseen difficulties, the issue of Vol. XIII., part I., was delayed until late in the Summer, instead of being issued in the Spring, as had been intended. They believe, however, that this delay has enabled them to complete their work in a more satisfactory manner than would otherwise have been possible, and hope that this explanation will be accepted by the members. A considerable amount of money has been expended on the illustration of this part, but they believe that the unusual excellence of the plates depicting the Lias Fishes of Whitby will fully compensate for the extra expenditure, and make this part of the Proceedings of world-wide value. They also believe that the experiment of issuing a series of photographs in place of one enlargement will approve itself to the members, and they desire to express their great indebtedness to Mr. Godfrey Bingley, of Headingley, for the splendid series of views of the Malham Dry Valley, which he generously allowed the Society to reproduce. The Council feel so confident that the issue of a series of photographs with the Proceedings will be found so much more convenient and useful to members than the enlargement previously issued, that they have decided to continue the same plan next year. Again Mr. Godfrey Bingley has generously placed his negatives at the disposal of the Council, and, availing themselves of his kindness, they have chosen a fine series of views of the Chalk of Flamborough Head to be issued with Vol. XIII., part II.

Just before our September Council Meeting, the sad news was received of the death of Professor A. H. Green, F.R.S., of Oxford, one of the Vice-Presidents of our Society. The Council unanimously decided to pass a resolution of respectful and sincere sympathy with Mrs. Green and her family in this great bereavement. It was resolved that "In Memoriam" notices of Mr. Thos. Hick and Professor Green should be inserted in the next part of our Proceedings.

At the request of the Council the Hon. Secretary has compiled a "Short History" of the Society, describing our history and aims, for the information of intending new members. Copies of this pamphlet can be had by any who can distribute them to advantage, on application to the Secretary, Hopton, Mirfield.

As in previous years, the Proceedings of the Society have been forwarded to leading Scientific Societies in various parts of the world, and our best thanks are due, and are hereby tendered, to the following Societies who have kindly sent their publications in exchange:—

British Association.
Royal Dublin Society.
Royal Geographical Society.
Royal Society of Edinburgh.
Royal Physical Society of Edinburgh.
Royal Society of Tasmania.
Department of Mines, Sydney, N.S.W.
Nova Scotian Institute of Science.
Royal Institution of Cornwall, Truro.
Royal Geological Society of Cornwall, Penzance.
Birmingham Natural History and Philosophical Society.
Essex Naturalists' Field Club.
Glacialists' Association.
Geological Association, London.
Geological Society of London.
Liverpool Geological Society.
Liverpool Geological Association.
Hampshire Field Club.
Hull Geological Society.
Herefordshire Natural History Society.
Manchester Geological Society.
Manchester Geographical Society.
Manchester Literary and Philosophical Society.

Leeds Astronomical Society.
Rochdale Literary and Scientific Society.
Warwickshire Natural History and Topographical Society.
Yorkshire Naturalists' Union.
American Philosophical Society, Philadelphia, U.S.A.
American Museum of Natural History, New York, U.S.A.
Academy of Natural Sciences, Philadelphia, U.S.A.
Boston Society of Natural History, Boston, U.S.A.
California State Mining Bureau, San Francisco.
Chicago Academy of Sciences.
Museum of Comparative Zoology at Harvard College, Cambridge, Mass.
Rochester Academy of Science, U.S.A.
United States Geological Survey, Washington, D.C.
Elisha Mitchell Scientific Society, University of N. Carolina, Chapel Hill, U.S.A.
Wisconsin Academy of Sciences, Arts, and Letters.
Konigelige Danske Videnskabernes Selscabs, Kjopenhavn.
L'Academie Royale Suedoise des Sciences, Stockholm.
Naturhistorischen Hofmuseum, Wien.
Royal University of Norway, Christiania.
Societé Imperiale Mineralogique de St. Petersburg.
Societé Imperiale des Naturalistes, Moscow.
Comité Geologique de la Russie, St. Petersburg.
Instituto Geologico de Mexico.
Sociedad Cientifica "Antonio Alzate," Mexico City.

Statement of Receipts and Expenditure of the Yorkshire Geological and Polytechnic Society, from 31st October, 1895, to 31st October, 1896.

REVENUE ACCOUNT.

Receipts.	£	s.	d.
To Balance in Treasurer's hands 31st October, 1895	16	11	3
,, Transfer from Capital Account ...	10	0	0
,, Subscriptions	60	15	6
,, Halifax Corporation Interest ...	10	3	0
,, Transfer from Wharfedale Exploration Fund	0	18	4
	£98	8	1

Expenditure.	£	s.	d.
By Green—Drawing Fish Plates ...	11	0	0
,, Baxendale's Rent—Wharfedale Exploration	2	0	0
,, Stationery, Printing, and Circulars ...	14	8	4
,, Plates for Proceedings	16	12	6
,, Photographs of the Malham Dry Valley	13	15	0
,, Griffin's Year Book of Scientific Societies	0	6	0
,, Geological Survey Maps	1	5	0
,, Expenses of Meetings	12	12	4
,, 1500 Pamphlets—Short History of the Society	4	0	0
,, Petty Cash and Postages	9	13	10
,, Balance in the Treasurer's hands ...	12	15	1
	£98	8	1

CAPITAL ACCOUNT.

	£	s.	d.
To Balance in Treasurer's hands 31st October, 1895	5	14	4
,, Life Members' Subscription (balance)	5	0	0
	£10	14	4

	£	s.	d.
By Transfer to Revenue Account ...	10	0	0
,, Balance	0	14	4
	£10	14	4

	£	s.	d.
To Balance	0	14	4
Halifax Corporation Bond	350	0	0
Capital ...	£350	14	4

Examined and found correct,

GEORGE PATCHETT, Auditor.

REPORTS OF MEETINGS.

Council Meeting, Philosophical Hall, Leeds, 31st March, 1896.

The chair was taken by Mr. Richard Reynolds, F.C.S.

Present :—Messrs. Stubbins, Kendall, and Carter (Hon Sec.)

The minutes of the previous Council Meeting were read and confirmed.

Letters of regret for non-attendance were read from Messrs. W. Gregson, W. Cash, C. W. Fennell, and T. Tate.

The Honorary Secretary reported that at Mrs. Davis' request he had been to Chevinedge and packed up the books belonging to the Society, and sent them to Mr. Henry Crowther for deposit in the Library of the Leeds Philosophical Hall. He reported that Mr. Crowther had kindly seen to their arrangement in the glass cases assigned to them, and that they were now available for reference at any time by Members.

The Council then inspected the books and expressed satisfaction with the arrangements made for their housing.

The recommendation of the previous Council Meeting that the next Meeting be held at Malham was confirmed. It was resolved that Mr. Walter Morrison, M.P., be invited to preside at the Meeting and Dinner, and that an invitation be sent to the Glacialists' Association. An outline programme was arranged.

Letters were read from Mr. Nicholas Carter, J.P., and Mrs. Crawford Williamson, in response to the votes of condolence passed at the Annual Meeting on the decease of Mr. Richard Carter, J.P., and Professor W. C. Williamson, F.R.S.

The Secretary reported that Mr. P. F. Kendall, F.G.S., was contemplating a detailed survey, on the six-inch scale, of the glacial deposits of the eastern side of the Pennine Chain. The facts had grown very rapidly, and the time was now ripe for attempting the thorough elucidation of these interesting glacial phenomena. This survey would entail a considerable outlay in maps, and he suggested that a grant, not exceeding £6, should be made to Mr. Kendall for the purchase of six-inch contour maps, on the understanding that the results of the survey should be communicated in papers to this Society, and that the maps when completed should be deposited in the library of our Society. The Secretary said he had consulted with the Treasurer on this matter and that he concurred in the recommendation. After some conversation it was resolved to postpone the consideration of the matter until the next Council Meeting.

The following accounts were passed for payment :—

	£	s.	d.
Green—Drawing Fish Plates	11	0	0
Mintern—Printing do.	6	2	6
F. Carter—Circulars, Stationery, and Plates for Proceedings	6	19	6
Waterlow—Collotypes (Malham Dry Valley)	13	15	0
	£37	17	0

General Meeting and Field Excursion at Malham, May 8th and 9th, 1896.

Friday, May 8th.—The party met at Bell Busk and went by waggonette to Malham. Kirkby Malham Church and its ancient registers were examined, and the Yoredale Beds in the bed of the beck. The route from Malham was through Gordale to the North Craven Fault, where the Upper Silurian Beds were seen. The party then proceeded to Tarn House, where luncheon was provided by the leader, Mr. Walter Morrison, M.P. The return journey was over Tarn Moss to the watersinks, and thence down the Dry Valley to Malham Cove, and on to Malham.

The Members dined together at the Buck Hotel.

The General Meeting was held after dinner, Mr. Walter Morrison, M.P., presiding.

Mr. Lewis Bradley, Bel Air, Alderley Edge, was elected a Member of the Society.

An address was delivered by the Chairman.

A paper on "Killing Pits," by Mr. J. R. Mortimer, was read by the Honorary Secretary.

An address on "The Drift Deposits of the Trent Valley" was delivered by Mr. P. F. Kendall, F.G.S.

A discussion followed, and a hearty vote of thanks to the Chairman was proposed by Mr. William Cash, seconded by Mr. Embleton, and carried unanimously. The Chairman briefly replied.

The arrangements for the next Meeting were considered. It was agreed to hold the next Meeting at Whitby, on July 31st and August 1st, and to co-operate with the Yorkshire Naturalists' Union at its Meeting at Staithes on the August Bank Holiday.

Saturday, May 9th.—An early start was made by road to the top of Malham Cove, where Mr. Morrison met the party. The route taken was over the moors to "Clattering Sykes," where a halt was called to secure specimens of the beautiful encrinities thrown out by the spring. The party then returned towards Kirkby Fell, and made for Stockdale Farm, near which an interesting quartz vein, on the line of the Craven Fault, was examined. Atteremere Scars were then climbed, and a visit paid to the Victoria Cave. Here the party separated from their leader, with many expressions of indebtedness, and made their way by Langcliffe to Settle. Most of the Members paid a visit to the Giggleswick Museum, where the relics found in the Victoria Cave were inspected with much interest.

Dinner was provided at the Lion Hotel, Settle, after which the Members separated.

Council Meeting, Crown Hotel, Whitby, 31st July, 1896.

The chair was taken by Mr P. F. Kendall, F.G.S.

Present :—Rev. J. Hawell, Mr. J. W. Stather, and the Honorary Secretary.

The Secretary reported that the stock of back parts of the Proceedings had been removed from Chevinedge. Messrs. Whitley and Booth had been unable to find storage room for them, and therefore he had applied to Mr. Henry Crowther, who had kindly undertaken to provide room in the library of the Leeds Philosophical Hall for their safe storage.

This arrangement was approved by the Council.

The proposal brought forward at the previous Council Meeting to provide Mr. Kendall with six-inch ordnance maps for the detailed survey of the glacial deposits of the western side of the Pennine Chain, was considered and adopted.

The following accounts were passed for payment :—

	£	s.	d.
Goodall & Suddick—Maps	1	5	0
F. Carter—Stationery, Circulars, and Plates for Proceedings	16	2	3
	£17	7	3

The Secretary read a letter from Lord Ripon, saying that he would endeavour to be present and preside at the Annual General Meeting at Wakefield in October.

The Council suggested Thursday, October 22nd, as a suitable date, but left the arrangements in the Secretary's hands to suit Lord Ripon's convenience.

The Secretary reported that, at his request, the Rev. John Hawell, M.A., had kindly consented to act as Local Secretary for the Middlesbrough District. This appointment was approved.

General Meeting and Field Excursion at Whitby, July 31st and August 1st, 1896. Leaders :—Messrs. P. F. Kendall, F.G.S., W. Y. Veitch, M.R.C.S., and the Rev. J. Hawell, M.A.

Friday, July 31st.—The Members met at Robin Hood's Bay, and made their way to Hawsker Bottoms by the shore. The cliffs were ascended at Hawsker, and the party walked back to Whitby. The Members dined together at the Crown Hotel.

Saturday, August 1st.—The 9-5 train from West Cliff Station brought the party to Peak, where some of the Members alighted and descended the cliffs to the shore. The rest of the party went on to Staintondale Station. A footroad was taken to the cliffs, and a descent made to Beast Cliff. After making way, with some difficulty, through the thick growth of trees, ferns and heather, a road was found down to the shore near Blea Wyke, and the rough mass of blocks which form the beach was traversed. Abundance of fossils were obtained from the Dogger Beds at Blea Wyke and the Alum Shale at Peak. After examining the fault at Peak, Robin Hood's Bay was crossed, and the party returned by train to Whitby.

After dinner the General Meeting was held at the Crown Hotel.

The chair was taken by Mr. Percy F. Kendall, F.G.S.

The minutes of the previous General Meeting were read and confirmed.

Letters of regret for non-attendance were read from the Rev. E. M. Cole, Messrs. J. R. Eddy, T. Tate, and C. W. Fennell.

The following new Members were elected :—

Benjamin A. Burrell, F.I.C., F.C.S., Leeds.
Richard T. Monson, M.R.C.S., L.R.C.P., Darlington.
Edwin Hawkesworth, Leeds.

The Chairman delivered an address on "The Origin of the Physiographic Features of East Yorkshire."

The following papers were read :—

"A History of the Dropping Well at Knaresborough and an Analysis of the Water," by Mr. B. A. Burrell, F.I.C., F.C.S.

"Notes on the Drifts of the Humber Gap," by Mr. John W. Stather, F.G.S.

"Notes on Elephas antiquus and other remains from the gravels at Elloughton," by Mr. Thomas Sheppard.

"The origins of some lines of small pits on Allerston and Ebberston Moors, near Scamridge Dykes, in the neighbourhood of Scarborough," by Mr. J. R. Mortimer.

A series of boulder-specimens found in the parish of Ingleby Greenhow, was exhibited and described by the Rev. John Hawell, M.A.

A vote of sympathy with Mrs. Hick and her family on the lamented death of Mr. Thomas Hick, B.Sc., A.L.S., was passed, on the proposition of the Hon. Secretary, seconded by Mr. Kendall, who made feeling references to Mr. Hick's valuable scientific work, and to the great loss sustained by his death.

Votes of thanks were passed to the Chairman, the Readers of the Papers, and the Leaders of the Excursion.

Monday, August 3rd. The party joined the Yorkshire Naturalists' Union in their excursion to Staithes. Train was taken to Easington and a visit paid to Boulby Alum Pit, a large excavation in the side of Boulby Cliff. After examining the sections and obtaining fossils, a return was made to the station and the train taken to Hinderwell. The village of Runswick was traversed and the shore followed to Staithes, numerous fossils being collected on the way.

The Members attended the General Meeting of the Yorkshire Naturalists' Union at Staithes

The party then returned to the Crown Hotel, Whitby, for dinner, after which the General Meeting was resumed for the discussion of the papers. Mr. Kendall's theory of the capture of the Ouse and its tributories by the Humber gave rise to an animated discussion in which Messrs. Stather, Walton, Carter, and the Rev. E. M. Cole joined. Mr. Kendall replied.

Council Meeting, Philosophical Hall, Leeds, September 8th, 1896.

The chair was taken by Mr. J. R. Eddy, F.G.S.

Present: Messrs. Kendall, Reynolds, Tate, Fennell, Wilkinson, and Carter (Hon. Secretary).

The Minutes of the previous Council Meeting were read and confirmed.

Letters of regret for non-attendance were read from Messrs. W. Gregson, J. E. Bedford, J. E. Wilson, and W. Rowley.

The Hon. Secretary exhibited a proof copy of the Proceedings, Vol. XIII., part I., ready for issue to the Members.

The Secretary reported that he had written to Mr. Godfrey Bingley, asking for the favour of the use of his negatives for the publication of a set of photographs in the next part of the Proceedings.

Mr. Bingley, in reply, had generously offered the use of any negatives desired by the Council.

Mr. Bingley then exhibited a number of excellent pictures of Yorkshire coast scenery which he had brought for inspection by the Council.

It was resolved that a series of photographic reproductions of the Chalk of Flamborough Head be issued with the Proceedings, Vol. XIII. part II., in lieu of the large photograph, for 1897

Resolved that Messrs. Kendall, Bingley and Carter be a Sub-Committee to choose the views.

The following resolution was moved by Mr. Richard Reynolds, seconded by Mr. J. R. Eddy, and carried :—

> "That the Council hereby record their sorrow at the death of one of the Society's valued Vice-Presidents, Professor A. H. Green, F.R.S., F.G.S., and offer to Mrs. Green and her family very respectful and sincere sympathy in their great bereavement."

It was resolved that Professor Miall be requested to prepare an "In Memoriam" notice of Professor Green, and Mr. W. Cash one of Mr. Hick, for publication in the next part of the Proceedings.

The Hon. Secretary read correspondence with Lord Ripon, and announced preliminary arrangements for the Annual General Meeting at Wakefield.

The Secretary reported the result of communications with Mr. W. D. Roebuck, with regard to the Coast Excursion next year. July 9th and 10th were suggested as suitable dates for an excursion to Scarborough and Hackness in conjunction with the Yorkshire Naturalists' Union.

After some conversation, Nidderdale was adopted as the area for exploration at the Spring Excursion.

The Secretary reported that he had received a letter from the Yorkshire College asking for the name of the Governor nominated by the Society to be forwarded. After some conversation as to the most suitable time for the Election of the Council's representatives to the Yorkshire College and the British Association, it was resolved :—

> "That the election of the representatives to the Yorkshire College and the British Association be made at the Spring Council Meeting, and that the nomination and election be by ballot."

Council Meeting, Bull Hotel, Wakefield, 29th October, 1896.

The Chair was taken by Mr. J. T. Atkinson, F.G.S.

Present: Messrs. Fennell, Simpson, Stather, Cash, Hawell and Carter (Hon. Secretary).

The Minutes of the previous Council Meeting were read and confirmed.

Letters of regret for non-attendance were read from Lord Ripon, Messrs. W. Horne, G. H. Parke, J. Stubbins, Platnauer, W. Gregson, R. Reynolds, W. Rowley, J. H. Howarth and Rev. E. M. Cole.

The following accounts were passed for payment :—

	£	s.	d.
Green—Drawing Fish Plates	11	0	0
Whitley & Booth—Proceedings	41	0	0
	£52	0	0

A letter was received from the Curator of the Whitby Museum asking for a copy of the Proceedings with Mr. Woodward's paper on "The Lias Fishes of Whitby." It was resolved that the Secretary be empowered to forward a copy to the Museum.

The Hon. Secretary read the Report for 1896, which, with one or two alterations, was adopted.

The Treasurer read his Financial Statement which was accepted for presentation to the Annual Meeting.

Annual General Meeting, Town Hall, Wakefield, 29th October, 1896.

The Chair was taken by Professor Arnold Lupton, F.G.S., M.Inst. C.E.

The Minutes of the previous Meeting were read and confirmed.

Letters of regret for non-attendance were read from Lord Ripon, Ven. Archdeacon Donne, Mr. C. J. Hudson (Town Clerk), Mr. Richard Porter (City Surveyor), Messrs. E. Hawkesworth, W. Horne, J. Stubbins, H. M. Platnauer, W. Gregson, J. E. Bedford, D. Forsyth, R. Reynolds, W. Rowley, and Rev. E. M. Cole.

The Mayor of Wakefield gave a genial and very hearty welcome to the Society to Wakefield.

The following new Members were elected :—

Arthur R. Dwerryhouse, Leeds.
Frederick Henry Wigham, F.C.S., Wakefield.
Richard Akeroyd, Wakefield.
Henry James Moreton, Outwood, near Wakefield.
Launcelot Dobinson, Stanley, near Wakefield.

The Hon. Secretary read the Annual Report.

The Hon. Treasurer presented the Financial Statement.

Resolved that the Secretary's Report and the Treasurer's Statement be adopted and printed.

The Officers and Council were then elected :

President :—

The Marquis of Ripon, K.G., F.R.S.

Vice-Presidents :

Earl Fitzwilliam.
Earl of Wharncliffe.
Earl of Crewe.
Viscount Halifax.
Dr. H. C. Sorby, F.R.S.
Walter Morrison, M.P.
W. T. W. S. Stanhope, J.P.
James Booth, J.P., F.G.S.
Dr. F. H. Bowman, F.R.S.E.
Richard Reynolds, F.C.S.
Wilfrid H. Hudleston, F.R.S., F.G.S.
J. Ray Eddy, F.G.S.

Hon. Treasurer :

William Cash, F.G.S.

Hon. Secretary :

William Lower Carter, M.A., F.G.S.

Members of Council :

J. T. Atkinson, F.G.S.
J. E. Bedford, F.G.S.
J. Ray Eddy, F.G.S.
David Forsyth, D.Sc., M.A.
P. F. Kendall, F.G.S.
Prof. A. Lupton, F.G.S.
G. H. Parke, F.L.S., F.G.S.
J. H. Howarth, F.G.S.
R. Reynolds, F.C.S.
Walter Rowley, F.G.S.
J. Stubbins, F.R.M.S., F.G.S.
Thos. Tate, F.G.S.

Local Secretaries :

Barnsley—T. W. H. Mitchell.
Bradford—J. E Wilson.
Driffield—Rev. E. M. Cole, M.A., F.G.S.
Halifax—W. Simpson, F.G.S.

Harrogate—Robert Peach.
Hull—John W. Stather, F.G.S.
Leeds—Henry Crowther, F.R.M.S.
Middlesborough—Rev. J. Hawell, M.A.
Skipton—J. J. Wilkinson.
Thirsk—W. Gregson, F.G.S.
Wakefield—C. W. Fennell, F.G.S.
Wensleydale—W. Horne, F.G.S.

The Chairman delivered an address on the Geology of Wakefield and District.

The following Papers were read :—

"Yorkshire Petrology, Part III., Analyses," by Mr. Thomas Tate, F.G.S.

"Description of two new species of Gastropods from the Yorkshire Lias," by Rev. J. Hawell, M.A.

"On the Fossil Fauna of the Middle Grits, at Eccup, near Leeds," by Mr. P. F. Kendall, F.G.S.

"On some Post-Pliocene changes in the Physical Geography of Yorkshire," by Mr. P. F. Kendall, F.G.S.

"On some Glacial Phenomena in the Western Himalayas," by Mr. Geoffrey Hastings, illustrated by a series of new lantern slides.

"On the Fossil Fishes of the Upper Lias of Whitby, Part II.," by Mr. A. Smith Woodward, F.L.S., F.G.S.

"Some Yorkshire Well-sections," by Mr. Wm. Whitaker, F.R.S., F.G.S.

"Norwegian Rhomb-porphyries in the Holderness Boulder-clays," by Mr. Alfred Harker, M.A., F.G.S.

"Ancient British Star-worship indicated by the grouping of Barrows," by Mr. J. R. Mortimer.

A selection of views of Flamborough was exhibited by Mr. Godfrey Bingley.

Votes of thanks were passed to the Mayor and Corporation of Wakefield, for the use of the Town Hall ; to the Executors of Mr. Dunn, and to the Victoria Coal and Coke Co., Limited, for permission to visit their pits, and to Mr. L. Dobinson for leading the party ; to the Chairman and the Readers of Papers ; to Mr. J. H. Chaplin for the loan and manipulation of the lantern ; and to Mr. Geo. Campbell for exhibiting a fine series of Carboniferous fossils.

The Members dined together at the George Hotel, under the presidency of Professor Arnold Lupton.

HONORARY MEMBERS.

1887 Bodington, Principal N., M.A., The Yorkshire College, Leeds.
1892 De Rance, Chas. E., C.E., F.R.M.S., 55, Stoke Road, Skelton, Stoke-on-Trent.
1887 Huges, Prof. T. McK., F.R.S., F.G.S., Cambridge.
1887 Judd, Prof. Jno. W., F.R.S., F.G.S., Science Department, South Kensington, London.
1887 Woodward Henry, Esq., LL.D., F.R.S., British Museum, (Natural History), Cromwell Road, London, S.W.

LIST OF MEMBERS.

Life members who have compounded for the annual subscriptions are indicated by an asterisk (*)

Elected.
1883*Abbott, R. T. G., Whitley House, Malton.
1875 Atkinson, J. T., F.G.S., Hayesthorpe, Holgate Hill, York.
1890*Ackroyd, W., F.I.C., Borough Analyst, Halifax.
1896 Akeroyd, Richard, Bond Street, Wakefield.

1879*Bartholomew, C. W., Blakesley Hall, near Towcaster.
1875 Bedford, James, Woodhouse Cliffe, Leeds.
1878 Bedford, J. E., F.G.S., Arncliffe, Shire Oak Road, Headingley, Leeds.
1895 Bingley, Godfrey, Thorniehurst, Shaw Lane, Headingley, Leeds.
1892 Binns, Thomas, Sawley Hall, Ripon.
1875*Booth, James, J.P., F.G.S., Spring Hall, Halifax.
1885 Bould, Chas. H., Ashgrove Cottage, Elland.
1876*Bowman, F. H., D.Sc., F.R.A.S., F.C.S., F.G.S., Ashleigh, Ashley Heath, Bowdon, Cheshire.
1896 Bradley, F. L., Bel Air, Alderley Edge, Cheshire.
1894 Branson, F. W., F.I.C., Commercial Street, Leeds.
1875*Brigg, John, M.P., F.G.S., Keighley.
1875*Briggs, Arthur, J.P., Cragg Royd, Rawden, Leeds.
1897 Broughton, W., Architect, Skipton.

1857 Brooke, Ed., F.G.S., Fieldhouse Clay Works, Huddersfield.
1877 Brooke, Lieut-Col. Thos., J.P., Armitage Bridge, Huddersfield.
1887 Brownridge, C., C.E., F.G.S., 26, North Road, Devonshire Park, Birkenhead.
1882*Buckley George, jun., Waterhouse Street, Halifax.
1896 Burrell, B.A., F.I.C., F.C.S., 5, Mount Preston, Leeds.

1892*Carter, W. Lower, M.A., F.G.S., Hopton, Mirfield.
1876*Cash, W., F.G.S., 35, Commercial Street, Halifax.
1891*Chambers, J. C., 14, St. John's Terrace, Belle Vue Road, Leeds.
1875*Charlesworth, J. B., J.P., Hurts Hall, Saxmundham.
1892 Child, Hy. Slade, F.G.S., Mining Engineer, Wakefield.
1877*Clark, J. E., B.A., B.Sc., 20, Bootham, York.
1878 Cole, Rev. E. Maule, M.A., F.G.S., Wetwang Vicarage, near York.
1889 Crewe, Earl of, Fryston Hall, Pontefract.
1897 Crofts, William Hastings, 60, Freehold Street, Hull.
1894 Crowther, Henry, F.R.M.S., The Museum, Leeds.

1879*Dakyns, J. R., M.A., of H.M., Geological Survey, 28, Jermyn Street, London, W.
1883 Dalton, Thos., Albion Street, Leeds.
1894*Davis, James Percy A., Chevinedge, Halifax.
1879 Dewhurst, J. B., Aireville, Skipton.
1886 Dobinson, Launcelot, Park View, Stanley, near Wakefield.
1891 Dodsworth, Sir Matthew, Bart., Sunningdale, Bournemouth.
1887*Duncan, Surr W., Horsforth Hall, Horsforth, near Leeds.
1896 Dwerryhouse, Arthur R., F.G.S., 65, Louis Street, Leeds.

1879 Eddy, J. Ray, F.G.S., Carleton Grange, Skipton.
1894 Embleton, Henry C., Central Bank Chambers, Leeds.

1895 Farrah, John, F.R.Met.S., Crescent Road, Harrogate.
1887*Fennell, Chas. W., F.G.S., 82, Westgate, Wakefield.
1839 Fitzwilliam, Earl, K.G., Wentworth Woodhouse, near Rotherham.
1883*Fleming, Francis, Elm Grove, Halifax.

1893 Forsyth, David, D.Sc., M.A., 2, Lifton Place, Leeds.
1894 Fox, C. E., P.A.S.I., 22, George Street, Halifax.
1891*Furness, Christopher, M.P., Brantford, West Hartlepool.

1890 Garforth, W. E., C.E., F.G.S., Halesfield, Normanton.
1875 Gascoigne, Col. F. C. T., Parlington Park, Garforth, near Leeds.
1883*Gaukroger, W., J.P., Fernside, Halifax.
1881 Gleadow, F., 38, Ladbroke Grove, London, W.
1875 Greaves, J. O., 69, Westgate, Wakefield.
1882 Gregson, W., F.G.S., Baldersley, S.O., Yorkshire.

1843 Halifax, Viscount, Hickleton Hall, Doncaster.
1878 Hallilay, J., 28, Burley Road, Leeds.
1895 Harker, Alfred, M.A., F.G.S., St. John's College, Cambridge.
1895 Hartley, Edward Tomson, M.A., The Grammar School, Skipton.
1887 Hastings, Geoffrey, 15, Oak Lane, Bradford.
1887 Hawell, Rev. Jno., M.A., Ingleby Greenhow, Middlesbrough.
1896 Hawesworth, Edwin, Nursery Mount, Hunslet, Leeds.
1895 Haworth, Ernest, Stanley Grange, near Wakefield.
1875 Holgate, Benj., F.G.S., 4, Montpelier Terrace, Headingley, Leeds.
1881 Horne, Wm., F.G.S., Leyburn.
1890*Howarth, J.H., F.G.S., Belvoir House, Heaton, Bradford.
1882*Hudleston, W. H., F.R.S., F.G.S., 8, Stanhope Gardens, South Kensington, S.W.

1894 Ianson, J. F., Cardigan House, Wakefield.
1895*Imbery John, Hyde Park Road, Halifax.

1887*Jones, J. E., Solicitor, Halifax.
1885 Jury, Samuel, Eleanor Street, Fartown, Huddersfield.

1888*Kerr, R. Moffat, Solicitor, Halifax
1892 Kendal, Percy F., F.G.S., 5, Woodland Terrace, Chapel-Allerton, Leeds.
1897 Kitson, R. H., Elmet Hall, Leeds.

1877*Lamplugh, G. W., F.G.S., of H.M. Geol. Survey, 28, Jermyn Street, London, W.
1875 Lancaster, Edward, Barnsley.
1894 Law, Arthur W., Greetland, Halifax.
1889 Lister, John, M.A., Shibden Hall, Halifax.
1897 Lofthouse, J. H., 42, Mayfield Grove, Harrogate.
1877*Lupton, Arnold, F.G.S., M.Inst. C.E., 6, De Grey Road, Leeds.

1897 Marsh, Henry Carpenter, Hurtswood, Roundhay, Leeds.
1891*Masham, Lord, Swinton Castle, Bedale.
1853 McLandsborough, J., F.G.S., F.R.A.S., 5, Lindum Terrace, Manningham, Bradford.
1892 Mitchell, Miss Hilda Carter, L.L.A., The Rectory, Bolton Abbey, Skipton.
1883 Mitchell, T. Carter, F.S.A., Topcliffe, Thirsk.
1889 Mitchell, T. W. H., Barnsley.
1896 Monson, Richard Taylor, M.R.C.S., L.R.C.P., Derneholme House, Darlington.
1896 Moreton, Henry James, Ivy Cottage, Outwood, near Wakefield.
1879*Morrison, Walter, M.P., Malham Tarn, near Leeds.
1878 Mortimer, J. R., Driffield.
1891 Morton, J. H., Broad Street, Halifax.
1894 Muff, Herbert B., Aston Mount, Heaton, Bradford.
1895 Muller, Harry, Granville Road, Sidcup, Kent.
1875*Myers-Beswick, W. B., 14, Victoria Street, Westminster, London, S.W.

1875 Nelson, Henry, St. John's Cottage, Leeds.
1889*Nicholson, M., J.P., Middleton Hall, near Leeds.
1894 Norton, A. E., Park Place, Parkinson Lane, Halifax.

1875*Parke, G. H., F.G.S., F.L.S., St. John's Villas, Wakefield.
1883 Patchett, George junior, Upper Shaw Hill, Halifax.
1892*Pawson, A. H., F.L.S., Lawns House, Farnley, Leeds.
1894 Peace, A. L., C.E., Thorne, Doncaster.
1883 Peach, Robert, James Street, Harrogate.

1891 Pearson, John T., The Hall, Melmerby, Thirsk.
1876 Pocklington, Henry, F.R.M.S., Park Row, Leeds.
1897 Pratt, Rev. Chas. T., M.A., Cawthorne Vicarage, near Barnsley.

1859*Ramsden, Sir J. W., Bart., M.P., Byram Hall, near Pontefract.
1864 Reynolds, Richard, F.C.S., Cliffe Lodge, Leeds.
1864*Rhodes, John, Snydale Hall, Pontefract.
1856*Ripon, The Marquis of, K.G., F.R.S., &c., Studley Royal, Ripon.
1888 Rowley, Brook, Weymouth Street, Halifax.
1869*Rowley, Walter, F.G.S., 20, Park Row, Leeds.
1875*Ryder, Charles, Westfield, Chapletown, Leeds.

1882 Scarborough Philosophical Society, The Museum, Scarborough.
1869 Seal, Stephen, F.G.S., Darfield Quarries, Barnsley.
1897 Sheppard, Thomas, 78, Sherburn Street, Hull.
1892*Simpson, W., F.G.S., The Gables, Halifax.
1885 Slater, E., Ashville, Farsley, near Leeds.
1887 Slater, M. B., 84, Newbiggin, Malton.
1897 Slater, G., Haltwistle, Carlisle.
1879 Slingsby, W. C., Carleton, near Skipton.
1876*Smith, F., The Grange, Lightcliffe.
1851 Sorby, H. C., D.C.L., F.R.S., F.G.S., Broomfield, Sheffield.
1875 Stanhope, W. T. W. S., J.P., Cannon Hall, Barnsley.
1881*Stansfeld, A. W., Skipton.
1890 Stather, J. W.. F.G.S., 16, Louis Street, Hull.
1894 Stears, John, Westholme, Hessle, Yorkshire.
1885*Stockdale, T., Spring Lea, Leeds.
1889 Stocks, Michael, Junior, Shibden Head, Halifax.
1878 Strangways, C. Fox, F.G.S., Abbotsbury House, New Walk, Leicester.
1879*Strickland, Sir Charles W., Bart., Hildenly, Malton.
1894 Stubbins, John, F.R.M.S., F.G.S., Ridge End, Wood Lane, Headingley, Leeds.
1894 Sutcliffe, J. W., 27, West View, Halifax.
1888 Sykes, Sir Tatton, Bart., Sledmere House, near York.

1897 Teal, Joseph, Grange Terrace, Yeadon, near Leeds.

1894 Tetley, Ed. H., B.A., Foxhills, Weetwood, Leeds.
1880 Tetley, C. F., M.A., Spring Road, Headingley, Leeds.
1889 Travis, Rev. W. Travis, M.A., Ripley, Yorkshire.
1886 Thompson, R., Drincote, The Mount, York.
1875*Tiddeman, R. H., M.A., F.G.S., of H.M. Geological Survey, 28, Jermyn Street, London, W.
1894 Thornton, Arthur, M.A., The Grammar School, Bradford.
1897 Tindall, George Fawcett, York Road, Tadcaster.
1875 Tute, Rev. J. Stanley, B.A., Markington Vicarage, Leeds.

1884*Walmisley, A. T., C.E., F.S.I., F.K.C., 5, Westminster Chambers, Victoria Street, London.
1894 Walton, F. Fielder, F.G.S., L.R.C.P., 19, Charlotte Street, Hull.
1875*Ward, J. Whiteley, J.P., F.R.M.S., South Royd, Halifax.
1839*Warncliffe, Earl of, Wortley Hall, Sheffield.
1840 Wheatley Charles, Sands House, Mirfield.
1890 White, J. Fletcher, F.G.S., 15, Wentworth Street, Wakefield.
1881*Whiteley, Fredk., Clare Road, Halifax.
1896 Wigham, Frederick Henry, F.G.S., Cherry Garth, Wakefield.
1889 Wilkinson, J. J., Burnside, Skipton.
1894 Williams, W. Clement, F.R.I.B.A., George Street, Halifax.
1890 Wilson, Edmund, Denison Hall, Leeds.
1894 Wilson, J. E., Yew Bank House, Ilkley.
1895 Wood, Frank, C.E., F.G.S., Town Hall, Wakefield.
1878 Woodall, J. W., J.P., F.G.S., Old Bank, Scarborough.
1878 Woodhead, Joseph, J.P., Longdenholme, Huddersfield.

*** It is requested that Members changing their residences will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1896.

Computed from daily observations made at the Exchange, Bradford, by JOHN McLANDSBOROUGH, M. Inst. C. E. retired, F.R.A.S., F.R. Met. Soc., F.G.S., and HENRY ARTHUR JOHNSON, Assoc. M. Inst. C.E.

Latitude, 53deg. 47min. 38sec. N.; longitude, 1deg. 45min. 4sec. W. Height above mean sea level, 366ft.

PRESSURE OF ATMOSPHERE IN MONTH.

MONTHS.	Highest Reading of Barometer.	Date	Highest during 28 Years.	Mean of Highest of 28 Years.	Lowest Reading of Barometer	Date	Lowest during 28 Years	Mean of Lowest of 28 Years	Range	Corrected for Capillarity and Temperature: Mean.	Corrected for Capillarity and Temperature: Mean of 28 Years
	Ins	On	Ins	Ins	Ins	On	Ins	Ins	Ins	Ins	Ins
January	30·450	[illegible]	30·65	30·196	[illegible]	[illegible]	[illegible]	[illegible]	1·736	[illegible]	[illegible]
February	[illegible]	3rd	[illegible]	30·117	28·334	20th	28·310	[illegible]	[illegible]	[illegible]	[illegible]
March	[illegible]	10th	[illegible]	30·122	28·272	4th	28·175	28·756	1·678	[illegible]	[illegible]
April	30·144	20th	30·50	30·066	[illegible]	29th	28·332	28·412	0·888	29·711	29·439
May	30·196	25th	30·432	30·174	[illegible]	2nd	28·661	29·078	0·644	29·669	29·561
June	29·900	19th	30·410	30·035	29·276	17th	28·840	29·181	0·644	29·529	29·518
July	[illegible]	[illegible]	30·365	29·978	29·410	26th	28·690	29·147	0·618	29·102	29·516
August	[illegible]	10th	30·232	29·968	29·276	6th	[illegible]	[illegible]	0·694	[illegible]	29·499
September	30·112	30th	30·232	30·077	28·532	22nd	28·452	[illegible]	1·580	[illegible]	[illegible]
October	30·112	1st	30·394	30·130	28·764	25th	28·250	28·750	1·348	[illegible]	29·440
November	30·304	25th	30·476	[illegible]	28·931	15th	[illegible]	[illegible]	1·374	29·762	29·469
December	29·972	27th	30·358	30·119	28·412	6th	27·652	28·660	1·560	29·337	29·470
Means, or totals	30·140		30·385	30·080	28·998		28·346	28·899	1·152	29·596	29·507

TEMPERATURE OF AIR IN SHADE DURING MONTH. — In Each Month.

MONTHS.	Highest.	Date.	Highest during 28 Years.	Mean of Highest of 28 Years.	Lowest	Date.	Lowest during 28 Years	Mean of Lowest of 28 Years	Range.
	Deg	On	Deg	Deg	Deg	On	Deg	Deg	Deg
January	53·8	3rd	57·2	[illegible]	26·7	21st	6·7	22·4	27·1
February	[illegible]	9th	[illegible]	[illegible]	26·0	26th	[illegible]	25·4	[illegible]
March	[illegible]	25th	66·0	57·2	32·2	[illegible]	17·4	26·1	24·8
April	63·0	28th	74·0	63·7	32·6	15th	25·0	31·3	30·4
May	77·0	13th	83·9	70·6	34·6	1st	28·6	[illegible]	42·4
June	80·4	16th	87·8	77·1	45·3	1st	38·0	42·0	[illegible]
July	80·4	21st	84·6	74·1	45·4	26th	42·0	46·9	35·0
August	66·6	14th	85·2	77·2	46·2	27th	[illegible]	45·4	20·4
September	66·6	28th	[illegible]	[illegible]	40·2	21st	33·5	[illegible]	26·4
October	62·0	3rd	69·9	62·9	28·6	27th	[illegible]	32·1	33·4
November	51·4	13th	61·5	56·5	27·0	6th	23·0	29·2	24·1
December	53·8	27th	67·8	63·1	27·4	1st	13·2	23·0	26·4
Means, or totals	63·9		72·8	64·5	34·3		25·2	33·3	29·6

TEMPERATURE OF AIR IN SHADE DURING MONTH. — Daily Mean; Adopted Mean Temperature.

MONTHS.	Daily Mean, In Each Month: Of all Highest	Mean of 28 Years	Of all Lowest	Mean of 28 Years	Range: Mean.	Range: Mean of 28 Years	Of Dry Bulb: Mean	Of Dry Bulb: Mean of 28 Years	Adopted Mean Temperature, Of Air: Mean	Of Air: Mean of 28 Years.	Of Evaporation: Mean.	Of Evaporation: Mean of 28 Years.	Dew Point: Mean	Dew Point: Mean of 28 Years
	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg
January	[illegible]	42·7	37·7	[illegible]	8·6	8·5	[illegible]	[illegible]	41·9	[illegible]	[illegible]	[illegible]	[illegible]	34·5
February	45·5	[illegible]	36·4	35·0	9·1	[illegible]	[illegible]	39·3	40·7	[illegible]	38·7	[illegible]	[illegible]	[illegible]
March	49·2	46·7	38·3	35·5	[illegible]	11·2	[illegible]	40·7	43·7	40·4	[illegible]	[illegible]	[illegible]	34·9
April	[illegible]	52·7	42·4	39·5	12·4	13·2	[illegible]	44·9	47·4	44·8	43·4	41·4	[illegible]	37·5
May	[illegible]	58·6	44·5	44·1	16·8	14·4	53·2	[illegible]	[illegible]	49·8	[illegible]	45·5	40·9	41·2
June	68·4	66·2	53·0	56·4	15·4	14·7	60·1	[illegible]	[illegible]	[illegible]	53·8	51·4	[illegible]	47·0
July	[illegible]	67·7	53·4	[illegible]	14·2	13·9	[illegible]	59·8	59·6	[illegible]	[illegible]	54·1	[illegible]	49·8
August	[illegible]	66·6	[illegible]	53·3	10·7	[illegible]	56·9	58·8	56·4	58·5	52·0	[illegible]	47·9	50·0
September	[illegible]	[illegible]	50·2	49·8	10·4	12·1	[illegible]	54·8	54·4	54·8	51·9	51·4	49·1	[illegible]
October	51·1	53·4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43·9	47·4	41·6	45·1	[illegible]	42·3
November	46·3	47·5	[illegible]	38·7	8·8	8·3	41·7	43·0	41·6	42·7	39	40·5	[illegible]	[illegible]
December	[illegible]	42·9	36·0	34·5	7·8	8·4	40·4	39·3	40·1	[illegible]	38·4	37·0	36·2	34·5
Means, or totals	54·7	54·2	43·4	42·7	11·3	11·5	48·8	47·8	48·5	47·5	45·0	44·4	[illegible]	41·0

VAPOUR.

MONTHS.	Elastic Force: Mean	Elastic Force: Mean of 28 Years	In a Cubic Foot of Air: Mean.	Mean of 28 Years	Short of Saturation	Mean of 28 Years	Mean Weight of a Cubic Foot of Air.	Mean of 28 Years	Degree of Humidity (Complete Saturation = 100): Highest	Date	Highest during 28 Years	Mean of Highest of 28 Years	Lowest	Date	Lowest during 28 Years	Mean of Lowest of 28 Years	Mean	Mean of 28 Years.
	Ins	Ins	Grs	Grs	Grs	Grs	Grs	Grs	0–100	On	0–100	0–100	0–100	On	0–100	0–100	0–100	0–100
January	[illegible]	201	[illegible]	[illegible]	[illegible]	0·4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	97	[illegible]	[illegible]	34	65	[illegible]	86
February	213	[illegible]	2·5	2·4	[illegible]	0·4	[illegible]	544	[illegible]	[illegible]	[illegible]	[illegible]	47	[illegible]	42	63	85	86
March	225	204	2·6	2·4	0·7	0·6	[illegible]	547	97	25th	[illegible]	[illegible]	[illegible]	[illegible]	23	54	78	82
April	237	[illegible]	2·7	[illegible]	[illegible]	0·6	542	[illegible]	94	26th	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	51	73	77
May	[illegible]	[illegible]	[illegible]	3·0	1·5	1·1	[illegible]	537	[illegible]	[illegible]	[illegible]	92	40	[illegible]	[illegible]	[illegible]	[illegible]	73
June	[illegible]	324	3·9	3·6	[illegible]	1·4	[illegible]	[illegible]	90	7th	100	[illegible]	[illegible]	2nd	32	47	[illegible]	72
July	[illegible]	359	3·8	4·0	1·1	[illegible]	527	[illegible]	88	8th	99	91	[illegible]	[illegible]	[illegible]	47	[illegible]	[illegible]
August	[illegible]	362	3·8	4·1	1·3	1·4	531	527	[illegible]	[illegible]	[illegible]	[illegible]	43	[illegible]	41	[illegible]	73	74
September	[illegible]	[illegible]	4·0	3·8	0·7	1·0	[illegible]	531	94	25th	99	95	[illegible]	[illegible]	[illegible]	54	[illegible]	78
October	237	272	2·7	[illegible]	0·6	0·6	[illegible]	[illegible]	97	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49	[illegible]	82	[illegible]
November	[illegible]	[illegible]	2·5	2·6	0·6	0·5	[illegible]	543	93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43	63	[illegible]	[illegible]
December	214	201	2·5	2·3	0·4	0·5	544	548	98	2nd	100	97	[illegible]	29th	44	62	[illegible]	84
Means, or totals	266	265	3·0	3·0	[illegible]	0·9	539	539	95		100	95	49		37	55	77	79

BRIGHT SUNSHINE. — **TEMP. OF AIR IN SUN'S RAYS.** — **WIND.** Direction: Relative Proportion of at 9 a.m.

MONTHS	Bright Sunshine: Greatest Daily Duration.	Date	Total of Month.	Per cent. of Possible Duration.	Temp. of Air in Sun's Rays: Highest.	Date.	Mean	N.	NE.	E.	SE.	S.	SW.	W.	NW.
	hr min	On	hr min		Deg	On	Deg	No	No	No	No	No	No	No	No
January	6 9	29th	17 40	7	70·0	29th	58·9	3	1	4	3	4	2	9	5
February	2 35	10th	11 35	4	78·0	10th	61·5	1	1	7	5	1	7	6	1
March	5 [illegible]	2nd	34 40	9	[illegible]	22nd	70·7	4	1	0	0	4	11	5	6
April	8 0	19th	61 50	16	97·0	19th	82·3	1	0	0	1	1	7	11	9
May	10 30	[illegible]	98 45	20	112·0	13th	91·7	5	9	0	0	0	4	4	9
June	11 30	29th	122 10	24	124·0	14th	104·3	2	5	4	2	1	3	11	2
July	12 40	6th	105 20	21	[illegible]	20th	99·6	3	3	3	1	5	2	[illegible]	1
August	6 10	22nd	69 50	15	105·0	17th	95·8	3	3	0	[illegible]	0	5	14	5
September	6 30	20th	47 40	13	100·0	16th	84·2	3	5	1	2	5	3	9	2
October	5 0	21st	49 35	15	88·0	5th	70·2	10	3	1	[illegible]	4	1	7	4
November	3 30	10th	23 25	9	76·0	4th	62·7	7	5	4	0	4	1	7	2
December	1 30	14th	4 0	2	66·0	12th	66·1	5	1	3	2	5	7	4	4
Means, or totals	6 30		[illegible]46 20	14	92·5		78·4	47	37	27	18	34	53	100	50

WIND. Velocity; Pressure.

MONTHS	Velocity at 9 a.m.: Mean	Highest.	Date	During 24 hours: Mean.	Mean of 10 years.	Highest.	Date	Highest of 10 years.	Total Registered in Month.	Mean of M'thly T't'l of 1[illegible] yrs	Highest M'thly T't'l of 10 yrs.	Pressure: Mean of all Daily Highest.	Mean of all Daily Highst. in 13 Years.	Highest.	Direction.	Date	Mean of Highest of Months of 13 Years
	Miles p'r h'r	Miles p'r h'r	On	Miles per d.	Miles per d.	Miles per d.	On	Miles per d.	Miles.	Miles	Miles.	lb. per sq ft	lb. per sq ft	lb. per sq ft		On	lb. per sq ft
January	5·6	14·6	16th	129	152	363	16th	473	4002	4700	6724	0·98	2·40	9·0	W	16th	9·98
February	4·9	14·0	8th	128	158	264	8th	593	3976	4499	6443	0·69	2·39	6·0	W	12th	9·62
March	8·2	22·4	6th	171	168	366	7th	559	[illegible]	[illegible]	5803	1·57	2·15	11·0	S E	17th	9·10
April	7·6	17·0	11th	150	138	305	11th	359	[illegible]	4144	5569	0·75	1·77	4·4	W	28th	6·74
May	7·1	[illegible]	6th	[illegible]	[illegible]	[illegible]	20th	[illegible]	4146	[illegible]	[illegible]	0·30	1·83	[illegible]	N	21st	6·43
June	5·4	13·0	21st	133	128	207	21st	282	3377	3824	4764	0·22	1·33	0·8	S	3rd	4·78
July	6·3	[illegible]	4th	149	[illegible]	[illegible]	5th	359	[illegible]	4223	4771	0·28	1·51	2·2	N N W	1st	5·46
August	6·0	11·4	24th	136	133	222	13th	493	[illegible]	4121	4603	0·20	1·53	1·0	W	14th	6·17
September	5·3	12·0	17th	116	128	298	18th	381	3493	3842	4873	1·14	1·72	5·0	S W	17th	6·08
October	5·0	15·0	8th	89	135	397	9th	397	2749	4176	5127	0·59	1·95	5·8	S S W	9th	8·57
November	2·7	12·5	2nd	62	143	179	11th	490	1357	[illegible]	[illegible]	0·20	2·14	1·3	N N W	21st	8·66
December	3·0	11·0	30th	78	136	306	31st	584	2454	4235	6440	0·35	2·41	2·9	S S W	27th	10·15
Means, or totals	5·6	14·5		124	140	285		446	45530	51305	5610	0·61	1·93	4·4			7·65

RAIN.

MONTHS	Mean Amount of Cloud.	Number of Days it fell.	Greatest Daily Fall.	Date.	Amount Collected.	Mean of 27 Years	Mean of Eight Years ending with 1882, 65¾ft above surface of ground.	Mean of [illegible] Yrs endg. with 1882 at T'n Hall and Mid Ry. Station on surface of ground.	Gr'ter fall on surface at Town Hall & Mid Stn than at 65¾ft. above surface at Exch: Depth in Inches.	Percentage of fall at Exch'ge
	0—10	No	Ins	On	Ins	Ins	Ins	Ins	Ins	Per cent
January	7·7	10	0·15	16th	0·74	2·53	2·209	2·474	0·265	11·2
February	8·1	5	0·26	29th	0·46	1·87	2·609	2·972	0·363	11·4
March	6·8	25	0·44	16th	3·30	2·15	2·776	3·260	0·484	11·7
April	6·5	13	0·35	11th	1·47	1·99	2·616	2·835	0·319	11·2
May	5·6	[illegible]	0·26	22nd	[illegible]	1·80	[illegible]	2·277	0·174	10·8
June	6·3	16	0·67	8th	3·76	2·32	2·837	3·011	0·174	10·6
July	6·2	[illegible]	0·40	25th	[illegible]	[illegible]	3·401	3·641	0·240	10·7
August	7·3	19	0·49	24th	1·28	2·57	3·654	3·892	0·238	10·7
September	7·7	27	0·86	25th	5·59	2·54	2·894	3·229	0·335	11·2
October	7·4	22	0·58	7th	3·88	3·64	3·640	4·012	0·372	11·0
November	7·0	[illegible]	0·52	8th	1·56	2·72	3·421	3·828	0·407	11·2
December	8·3	23	0·58	28th	3·77	2·67	3·681	4·170	0·489	11·3
Means, or totals	[illegible]	[illegible]	0·48		28·45	29·63	35·741	39·601	3·860	11·08

METEOROLOGY OF BRADFORD FOR 1896

YEARLY MAXIMUM AND MINIMUM ATMOSPHERIC PRESSURE, TEMPERATURE, HUMIDITY, BRIGHT SUNSHINE, WIND PRESSURE, AND RAINFALL.

Year.	PRESSURE. Highest. Reading of Barom during Year.	PRESSURE. Highest. Date.	PRESSURE. Lowest Reading of Barom during Year	PRESSURE. Lowest Date.	TEMPERATURE. In Shade Highest R'ding of Maximum Thermom during Yr	TEMPERATURE. In Shade Highest Date	TEMPERATURE. In Shade Lowest R'ding of Minimum Thermom during Yr	TEMPERATURE. In Shade Lowest Date	TEMPERATURE. Last and First Frost of Seasons Date of Last Frost	TEMPERATURE. Last and First Frost of Seasons Date of First Frost	TEMPERATURE. In Sun's Rays Highest Reading of Solar Thermom during Yr	TEMPERATURE. In Sun's Rays Highest Date	HUMIDITY. (Complete Saturation = 100) Highest Degree of Humidity during Yr	HUMIDITY. Highest Date.	HUMIDITY. Lowest Degree of Humidity during Yr	HUMIDITY. Lowest Date	BRIGHT SUNSHINE. Greatest Daily Duration	BRIGHT SUNSHINE. Date.	BRIGHT SUNSHINE. Total of Year.	BRIGHT SUNSHINE. Per cent of Possible Duration	WIND PRESSURE. Highest	WIND PRESSURE. Date	RAIN. Total for Year	RAIN. Mean Y'ly Rainfall at Town Hall and Mid Rly Stn on surface of g'nd	RAIN. Gr'tr. fall on srfce. at T'n H'll & Mid Stn than at 65 ft ab've surf at Exe Depth in Inches	RAIN. Gr'tr. fall Percentage of fall at Exch'ge	RAIN. Greatest Daily Fall during Yr.	RAIN. Date	Snow Last and First Snow of Seasons Date of Last Snow.	Snow Date of First Snow
	Ins		Ins		Deg		Deg.				Deg		0 100		0–100		hr min		hr min		lb per sq. ft.		Ins.	Ins.	Ins.	Per cent	Ins			
1869	30·290	Dec. 6	28·500	Feb. 1	85·2	Aug. 30	19·8	Dec. 28	Mar. 27	Oct. 20	127·7	Aug. 30	99	Feb. 8	42	Sep. 24	......	......	......	......		......	......	......	......	......	...	......	April 3	Oct. 19
1870	30·284	Jan. 19	28·308	Jan. 8	85·0	July 25	16·6	Dec. 23	Mar. 30	Nov. 9	127·5	July 25	98	Jan. 29	28	Mar. 6	......	......	......	......	......	......	24·120	......	......	......	0·820	June 18	Mar. 24	Nov. 15
1871	30·152	Mar. 28	28·308	Jan. 16	84·0	Aug. 12	6·7	Jan. 1	April 11	Nov. 13	128·7	July 17	98	July 7	43	Nov. 2	......	......	......	......	......	......	21·640	......	......	......	0·985	June 16	Mar. 15	Nov. 16
1872	30·156	April 6	28·070	Jan. 24	86·4	July 23	24·8	Mar. 27	Mar. 27	Nov. 19	124·8	Aug. 19	100	Mar. 22	45	Sep. 23	......	......	......	......	......	......	42·060	......	......	......	2·490	June 19	May 11	Nov. 13
1873	30·338	Feb. 18	28·022	Jan. 20	88·8	July 23	19·2	Feb. 24	Mar. 14	Nov. 5	124·5	July 23	100	Dec. 11	41	Mar. 26	......	......	......	......	......	......	21·440	......	......	......	1·200	Aug. 4	April 25	Jan. 3, '74
1874	30·476	Mar. 6	28·276	Dec. 11	80·9	July 20	15·0	Dec. 31	Mar. 12	Nov. 11	126·8	July 20	100	Feb. 6	42	May 18	......	......					23·560	..		.	0·740	Dec. 7	May 9	Nov. 26
1875	30·305	July 7	28·484	Nov. 10	80·0	Aug. 17	13·0	Jan. 1	Mar. 22	Nov. 26	122·0	July 5	100	Jan. 23	43	July 6	......	......	......	......	......	......	30·280	......	......	......	1·700	Nov. 15	Mar. 12	Nov. 9
1876	30·300	Jan. 15	28·070	Dec. 4	87·6	July 17	23·0	Jan. 9	April 15	Nov. 9	125·6	July 16	99	Oct. 4	46	May 5	......	......	......	......	......	......	35·270	39·788	4·518	11·28	1·810	Oct. 9	April 12	Nov. 8
1877	30·558	Oct. 6	28·300	Nov. 29	80·0	June 19	20·0	Mar. 1	May 4	Oct. 18	116·4	June 19	100	Oct. 29	35	May 23	......	......	......	......	......	......	40·650	45·499	4·849	11·19	1·420	July 16	May 19	Oct. 15
1878	30·320	Mar. 16	28·630	April 1	89·6	July 19	13·9	Dec. 26	April 6	Nov. 9	118·2	July 22	99	Jan. 13	53	Aug. 9	......	......	......	......	......	......	35·434	39·010	3·576	11·01	1·220	Aug. 14	April 1	Nov. 8
1879	30·352	Dec. 13	28·500	Feb. 10	74·4	July 30	13·2	Dec. 7	May 10	Nov. 14	101·2	Aug. 13	100	Oct. 7	51	Dec. 12	......	......	......	......	......	......	28·017	30·298	2·281	10·82	1·020	June 8	May 7	Nov. 20
1880	30·332	Jan. 7	28·154	Nov. 16	81·3	Sep. 5	20·8	Jan. 20	Feb. 23	Oct. 20	112·0	Aug. 13	99	Dec. 15	50	May 30	......	......	......	......	......	......	35·690	39·616	3·926	11·10	1·710	Oct. 27	Mar. 2	Oct. 27
1881	30·382	May 10	28·250	Oct. 14	83·3	July 6	12·0	Jan. 26	April 21	Oct. 17	116·5	June 1	98	Oct. 14	38	May 31	......	......	......	......	......	......	35·434	39·892	4·458	11·26	1·435	Oct. 13	April 20	Oct. 29
1882	30·644	Jan. 18	28·452	Mar. 1	77·4	Aug. 12	18·6	Dec. 11	April 16	Nov. 12	108·0	Aug. 9	99	Nov. 5	36	May 18	......	......	......	......	......	......	39·683	43·103	3·420	10·86	1·608	Dec. 6	Mar. 21	Nov. 19
1883	30·500	April 9	28·452	Sep. 2	76·2	July 3	19·8	Mar. 10	Mar. 29	Nov. 12	107·6	May 17	99	Dec. 26	30	April 9	......	......	......	......	......	......	34·396	......	......	......	1·338	Sep. 26	Mar. 24	Nov. 10
1884	30·554	Oct. 5	28·376	Jan. 27	84·4	Aug. 12	26·5	Nov. 30	April 24	Nov. 24	107·8	Aug. 9	98	Jan. 23	30	May 22	......	......	......	......	24·00	Jan. 24	27·657	......	......	......	1·170	Jan. 23	Feb. 28	Nov. 23
1885	30·273	Mar. 14	28·400	Jan. 11	82·2	July 27	22·1	Dec. 11	April 5	Nov. 16	113·6	July 27	100	Jan. 23	32	June 4	......	......	......	......	15·25	Dec. 4	25·699	......	......	......	1·208	Sep. 3	May 7	Dec. 9
1886	30·355	Nov. 24	27·652	Dec. 8	74·5	July 3	17·4	Mar. 7	April 30	Dec. 2	108·8	July 5	99	Jan. 12	32	May 4	11 45	July 6	851 48	19	18·00	Dec. 9	35·993	......	......	......	2·130	July 26	May 12	Nov. 6
1887	30·412	Feb. 8	28·328	Nov. 3	82·8	July 9	21·1	Jan. 17	April 17	Oct. 12	107·6	July 9	100	April 21	35	July 9	12 40	July 3	1120 58	25	15·00	Feb. 4	18·665	......	......	......	0·810	Oct. 9	May 21	Oct. 14
1888	30·333	Jan. 10	28·410	Mar. 28	80·4	June 27	19·2	Feb. 14	April 8	Oct. 2	110·0	Sep. 15	99	Mar. 15	39	June 11	13 40	May 24	984 20	20	13·00	May 4	25·646	......	......	......	1·050	Nov. 3	April 8	Oct. 1
1889	30·358	Dec. 5	28·400	Mar. 20	77·5	Aug. 1	21·3	Mar. 4	Mar. 22	Nov. 27	115·2	June 23	99	April 22	39	June 26	12 15	July 8	827 45	18	12·00	Feb. 9	22·141	......	......	......	0·590	Mar. 9	Mar. 21	Nov. 25
1890	30·376	Feb. 23	28·315	Jan. 23	76·4	Sept. 10	18·4	Dec. 22	Mar. 10	Oct. 28	111·0	June 16	99	May 11	31	May 29	14 25	May 25	824 5	18⅓	14·00	Jan. 19	26·730	......	......	......	1·485	Jan. 22	April 13	Oct. 21
1891	30·394	Oct. 31	28·060	Nov. 11	79·9	Sept. 12	12·0	Jan. 19	May 18	Nov. 26	107·0	July 27	100	Feb. 20	37	July 17	11 45	May 12	805 35	18	13·60	Aug. 26	27·303	......	......	......	1·020	Dec. 10	May 17	Nov. 26
1892	[illegible]	Mar. 30	28·658	Feb. 2	77·0	Aug. 24	18·8	Feb. [illegible]	April 19	Oct. 25	107·5	July 23	99	Jan. 12	32	April 3	12 31	June 7	866 53	19	10·00	April 28	[illegible]	. .			[illegible]	Oct. 15	April 28	Oct. 24
1893	30·558	Dec. 30	28·360	Feb. 26	85·0	Aug. 19	19·0	Jan. 5	April 12	Oct. 31	117·8	Aug. 19	98	Mar. 1	37	April 25	13 0	May 10	980 36	22	13·20	Nov. 19	22·667	......	......	......	1·180	May 18	Mar. 17	Nov. 5
1894	30·302	Dec. 27	28·512	Oct. 25	[illegible]	July 1	[illegible]	Jan. 6	Mar. 17	Oct. 22	[illegible]	July 9	100	Jan. 8	40	July 5	12 46	July 1	[illegible]	17	18·00	Dec. 2	[illegible]				[illegible]	Oct. 27	Mar. [illegible]	Dec. [illegible]
1895	30·270	May 4	28·218	Mar. 28	75·0	May 31	9·4	Feb. 8	Mar. 12	Oct. 28	110·0	May 27	98	April 18	40	May 6	12 30	June 8	802 22	18	16·20	Dec. 5	30·491	......	......	......	1·600	June 27	April 7	Oct. 26
1896	[illegible]	Jan. 9	28·272	Mar. 4	[illegible]	June 16	26·0	Feb. 26	Feb. 27	Oct. 16	[illegible]	June 14	93	Feb. 20	35	June 2	12 41	July 6	[illegible]	14	[illegible]	Mar. 17	[illegible]				[illegible]	Sep. 25	Mar. 26	Oct. 11
Means.	30·349		28·314		81·5		17·8				115·4		99		39		12 43		652 65	19	14·78		29·622	39·601	3·860	11·08	1·349			

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p.m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level (the air temperature being 48 degrees and barometer 30 inches at sea level), add ·401 inch to the heights given.

A remarkable instance of barometric depression occurred on the 8th December, 1886, when at 8.40 p.m. the mercury of the Exchange barometer had fallen to 27·456 inches only—the lowest reading on record here. The cyclone indicated by this depression was the cause of great loss of life and property, extending over an unusually large district.

All thermometric observations and deductions are given in degrees Fahrenheit.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition.

Bright sunshine is recorded in hours and minutes by glass sphere on cards, known as Campbell's recorder, fixed on Professor Stokes' zodiacal frame.

The solar thermometer has a black bulb enclosed in a vacuum.

The direction, velocity, and pressure of wind are recorded as indicated by anemometers fixed 10½ feet above the ridge of roof of Exchange. The velocity per hour at 9 a.m. is determined from anemometer readings made one minute and a half before and a like period after that hour, by multiplying the difference thereof by 20. The pressure is given in pounds avoirdupois per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10.

Rainfall includes melted snow and hail.

The rain gauge is fixed upon the top of central roof of the Exchange, at an elevation of 65½ feet above the surface of the ground and 395 feet above mean sea level. As rain gauges on the summit of buildings are generally found to collect less rain than when placed upon the surface of open ground adjacent thereto, steps were taken in 1876 to determine to what extent this was the case with the Exchange rain gauge, when two additional gauges were provided and fixed upon the surface of adjacent open spaces, one near to the Town Hall, the other near to the Midland Railway Station, between which the Exchange gauge is situate about midway, and the surface of ground about the same height. At both of these gauges, as well as at the Exchange gauge, daily observations were made from the commencement of 1876 to the end of 1882, a period of seven years, when the surface gauges were removed in consequence of the ground they occupied being no longer available for the purpose. The particulars of these gaugings are set forth in tables. The results show that the mean yearly rainfall on the surface of ground for the seven years ending with 1882 is 3·86 inches, or 11·08 per cent., greater than at the summit of the Exchange. The mean yearly rainfall recorded at the Exchange for the twenty-seven years ending with 1896 is 29·622 inches. By adding 11·08 per cent. thereto the mean normal rainfall of central Bradford for such period is found to be 32·904 inches per annum. There are good grounds for concluding that the smaller amount of rainfall collected on the Exchange—and on buildings generally—than on the surface of ground is due to the varying direction and force of wind there producing different currents and eddies, which prevent due precipitation on the top or ridge of roof where the gauge is fixed. The rainfall of 1869 was collected by a gauge placed on the ridge of outer roof of Exchange, near to the north-west corner thereof. This position not being deemed quite satisfactory, the gauge was removed at the end of that year to the ridge of central roof—the place it has since occupied. To avoid risk of inaccurate results, the rainfall of 1869 is omitted from these returns.

The instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory, excepting those which can be verified by measurement.

PROCEEDINGS
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YORKSHIRE
GEOLOGICAL AND POLYTECHNIC SOCIETY.

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With Ten Plates,
and Eight Photographs of Filey Bay and Brigg.

Edited by W. LOWER CARTER, M.A., F.G.S.,
and WILLIAM CASH, F.G.S.

1898.

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1897.

NORWEGIAN RHOMB-PORPHYRIES IN THE HOLDERNESS BOULDER-CLAYS.

BY ALFRED HARKER, M.A., F.G.S.

(*Read October 29th*, 1896.)

[Abstract.]

Among the various rocks of Scandinavian origin, boulders of which occur in our east-coast boulder-clays, and have been utilised by Glacial geologists in tracing the movements of the Pleistocene ice, none are better adapted for this purpose than the rhomb-porphyries. Not only have they a striking and easily-recognized characteristic in the peculiar crystallographic habit of their porphyritic felspars, which causes them to present rhombic sections on a face of the rock, but in this and other peculiarities they are unique or almost unique* among known rocks. They are thus among the few boulders which can be set down at a glance and without fear of error as having their source in a defined foreign area.

Although this conclusion seems beyond doubt, it may, perhaps, be thought to be strengthened by the cumulative evidence derived from the identification among our boulders, not only of rhomb-porphyries, but of particular varieties of rhomb-porphyries, which

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* Osann has described rhomb-porphyries from Texas.

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have been distinguished as such in their Norwegian home. The occurrence of rhomb-porphyry boulders at Bridlington, Dimlington, and other places on or near our east coast has long been known, but nothing more than a cursory notice of them has yet appeared. For a full description and comparison we must wait until the several types have been more completely and systematically described by the Norwegian geologists: the only object of the present notice is to point out that the Holderness boulders comprise more than one of the types already known in Norway.

Brögger, in his work on the eruptive rocks of the Christiania basin, regards the rhomb-porphyries as constituting what he styles a "rock-series," that is, an assemblage of types referable to different families and exhibiting considerable differences, but having well-marked characters in common and occupying similar classificatory positions in their several rock-families. Ranging the several types with the different plutonic rocks of the district to which they belong, he distinguishes:

Plagioclase-rhomb-porphyry corresponding with Olivine-Gabbro-Diabase [Essexite],
Common rhomb-porphyry corresponding with Laurvikite or Augite-Syenite,
Nepheline-rhomb-porphyry corresponding with Laurdalite or Nepheline-Syenite,
Quartz-rhomb-porphyry corresponding with Nordmarkite or Quartz-Syenite.

The majority of the rhomb-porphyry boulders which have come under my notice fall under the second head, but some at once separate themselves from the common varieties. A specimen received a year ago from Mr. T. Sheppard is an example. It shows the grey or partly flesh-coloured porphyritic felspars, with the usual rhomb-shaped section and imperfect outline, set in an evidently crystalline ground-mass which marks the rock as one of the intrusive varieties rather than a lava-flow. The conspicuous elements of this ground-mass to the eye are a reddish felspar and a dark augite, but a thin slice reveals in addition a noteworthy amount of clear quartz. The manner of association of this mineral with the felspar, tending to form a rude graphic intergrowth, bespeaks a primary origin for the whole. The augite, very faintly coloured in the thin slices, is in rounded or irregular crystal-grains, which, however, must belong to an early stage of crystallization, for they are sometimes enclosed in the porphyritic felspars. This remark applies also to the two remaining constituents, viz., imperfect crystals of magnetite and little hexagonal prisms of apatite.

We clearly have to do here with a quartz-rhomb-porphyry, a rock of more acid composition than the common types. A specimen of a more basic type, a plagioclase-rhomb-porphyry, I have also examined from the Holderness boulder-clay. Doubtless further search may be expected to reveal the nepheline-bearing rock too, and to add varietal forms under each of the four heads specified. The student of igneous rocks in East Yorkshire, while lacking material from the "solid" geology of his district, has an inexhaustible store-house open to him in the spoils of the Norwegian ice-sheet.

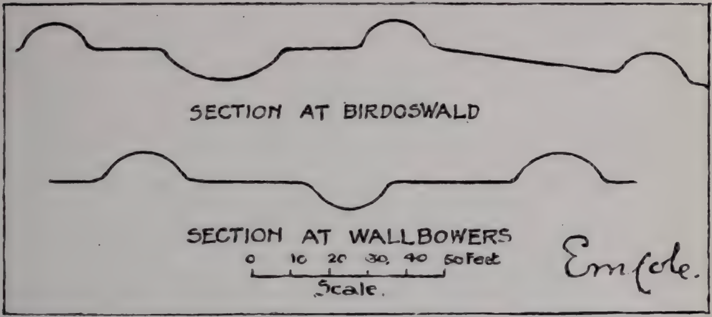
NOTE ON THE VALLUM IN RELATION TO THE ROMAN WALL FROM NEWCASTLE TO CARLISLE.

BY THE REV. E. MAULE COLE, M.A., F.G.S.

(*Read May 22nd*, 1897.)

Last year Professor Hughes, of Cambridge, kindly sent me some 50 of his papers bearing chiefly on geological subjects. Among them was one dealing with the above-named Vallum from a British standpoint, advocating the view that the Britons might have constructed the Vallum as a defence against the Roman invaders advancing from the south. This idea strongly attracted me, for it was urged with ability and authority, but I felt that the point could not be conceded without personal investigation. It so happens that for the last thirty years I have had exceptional advantages for studying undoubted British entrenchments on the Yorkshire Wolds, and naturally thought that the experience thus gained would serve to elucidate the problem. I therefore suggested to my friend, Mr. J. R. Mortimer, of Driffield, whose knowledge on the subject of entrenchments is very extensive, that we should make an excursion and examine a portion, at least, of the Vallum with minds unprejudiced; though I am bound to confess that my own views were strongly impressed by the arguments of Professor Hughes.

We started accordingly in June (1896) and took up our abode at Gilsland Spa, within easy reach of the Wall, Camps, and Vallum. We examined carefully every feature westward to Hare Hill, near Lanercost, and eastward to Borcovicus or Housesteads, and took sections of the Vallum. What struck me most was the extreme rectilinear line of the entrenchments from one point to another, so unlike the irregular line of earthworks to be seen at the Danes' Dike, Huggate Dikes, and other entrenchments on the Wolds of the East Riding. This was, perhaps, most noticeable some half-mile to the west of Birdoswald, the Roman station of Amboglanna. The line of entrenchments is here absolutely straight, as if ruled by a ruler. In this portion of the Vallum there is an additional ditch and mound, not found elsewhere, facing the *north*; there is no appearance of a special defence facing the *south*, as contended for by some writers. The nature of the ground here is against any attack from the south, and the entrenchments were evidently thrown up rather with a view to meet assault from the north; but only at this locality; several sections taken elsewhere show no preference for either south or north. The general idea is shown in the following woodcut:—



As originally constructed, the earthworks exhibit a central fosse, followed on either side by a level platform (which is not found in British entrenchments) and enclosed by an agger. Of course this plan has been greatly altered in the lapse of centuries, partly by natural causes, partly by artificial ones, such as the plough, the construction of the modern military road, and quarries. At one point, about half-way between Æsica (Great Chesters) and Magna (Carvōran), we noticed a complete obliteration of the Vallum along the line of some ancient quarries of sandstone, which gave us the impression that the Romans had at this point utilized the sandstone for building the Wall, and disregarded the destruction of the Vallum, which, if correct, undoubtedly suggests that the Vallum was older than the Wall, and was no longer considered of vital importance. Still, the Vallum might have been Roman work, and probably was, *pace* Professor Hughes. The platforms on either side of the central fosse are utterly unlike any British entrenchments which exist on the Yorkshire Wolds, and my humble opinion is that (1) the Vallum is a Roman work, not British, and (2) constructed at an earlier date than the Wall, but with a somewhat similar design of forming a barrier against attack from south or north, and of offering a ready communication between a line of military posts.

THE COMPOSITION OF THE SPAR OCCURRING IN MOTHER SHIPTON'S CAVE, KNARESBOROUGH.

BY B. A. BURRELL, F.I.C.

(*Read October* 7*th*, 1897.)

The occurrence of Strontium Sulphate at Knaresborough had been noticed as early as 1811, for in the Transactions of the Geological Society, vol. iv. p. 445, we find an extract from the minute book stating "that a letter from Dr. Murray, of Harrogate, to Mr. Sowerby, was read mentioning that sulphate of strontian had been found on the banks of the Nidd, near Knaresborough."

The Edinburgh Phil. Journal, Jan. 1825, vol. xii., p. 178, 179, also refers to the same subject. "Most of the native combinations of strontites, have of late been found by Dr. Peter Murray in the W. R. of the County of York, in the vicinity of Knaresborough. . . . Of the sulphate, three varieties have been noticed upon the banks of the Nidd, near Knaresborough."

Strontium in the form of Carbonate is found in the Bilton Spa Water (Attfield's analysis), and the writer has shown that it is also present in the water of the Dropping Well as sulphate.*

It is evident that Strontium compounds occur to some considerable extent in this district, and it seemed to be an interesting point to ascertain whether they were present in more than the very small traces which Roscoe states are to be generally found in many kinds of limestone.†

The analysis of the spar occurring in Mother Shipton's Cave is now submitted as a first instalment to the solution of this question. The spar may be seen in fissures of the rock at the back of the cave, and from its appearance it is evidently the deposit from some ancient calcareous spring, whose waters have been highly charged with Carbonic Acid, thus enabling them to dissolve large quantities of

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* Transactions of the Chemical Society, May 1896, vol. 69. Proc. Yorksh. Geol. & Polyt. Soc., vol. xiii., pt. ii., 1896.

† Roscoe & Schorlemmer. Treatise on Chemistry, vol. ii., pt. i., p. 213.

Calcium Carbonate. Small pieces are quarried from time to time by the lessee of the Mother Shipton Inn, and sold as *deposit from the water*. This is somewhat misleading, as visitors naturally expect it to be the deposit from the Dropping Well water. The spar is crystalline, of a rich brown colour, very hard, and takes a fine polish.

100 parts of the air-dried spar contain :—*

Silica (SiO_2)	0·037
Phosphoric Acid (P_2O_5)	0·005
Sulphuric Acid (SO_3)	2·331
Carbonic Acid (CO_2)	42·170
Calcium Oxide (CaO)	55·038
Magnesium Oxide (MgO) ...	0·190
Strontium Oxide (SrO)	0·128
Manganic Oxide (Mn_3O_4) ...	0·019
Ferric Oxide (Fe_2O_3)	0·006
Alkalies, &c.	traces.

These constituents may be combined as follows :—

Silica	0·037
Calcium Carbonate	95·494
Calcium Sulphate	3·793
Strontium Sulphate	0·227
Magnesium Carbonate	0·397
Oxide of Manganese	0·019
Ferric Phosphate...	0.010
Alkalies, &c. (by diff.)	0·023
	100·000

The spar is therefore mainly composed of Calcium Carbonate, with about three and three-quarters per cent. of Calcium Sulphate, and nearly one quarter per cent. of Strontium Sulphate.

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* The atomic weights used are those given in Clowes & Coleman's Quantitative Analysis, 1894.

A SUMMARY OF WHAT IS KNOWN OF THE SO-CALLED "DANES' GRAVES," NEAR DRIFFIELD.

BY J. R. MORTIMER, DRIFFIELD.

Read October 7th, 1897.

The following is a summary, so far as I have been able to gather, of what has been written and what is known respecting this group of burial mounds.

These mounds, covered by the trees of an old plantation, may be seen in a little valley within the boundaries of the Lordships of Driffield and Kilham, in the East Riding of Yorkshire, nearly four miles due north of Driffield.

They measure from 1 ft. to 3½ ft. in height and 9 ft. to 33 ft. in diameter. The place has from time immemorial been called "Danes' Graves" and "Danesdale." Some accounts say there were originally 500 at least of these mounds; but on the Ordnance Map 197 is the number given. Their comparative preservation seems to be due entirely to the protection afforded by the old trees growing on them. Very probably they once extended, on two sides at least, beyond the boundary of the plantation into the adjoining fields, but there the plough has obliterated all surface trace of them. Many of them within the plantation have been more or less levelled, and some wholly obliterated by persons digging for rabbits; while others have been frequently excavated at various periods by relic seekers and the otherwise curious, who have left no authentic account of their finds.

I. The first written record respecting these barrows is given by Leland more than 300 years ago. He says: "Adjacent to Driffield there is a field called the 'Danish Field,' observable for the many mounds of the slain; and there is a current report that, by the chance of war, a king fell on that field, whilst the tyranny of the Danes raged in those times."

II. The next notice of them which I possess is by Sir William Dugdale, in 1666, who saw these mounds and in his Book of Arms in the Heralds' College makes the following note of them :—

"Memorandum—that about two miles south-westwards of Kilham, on the Wolds, at the skirt of the rising ground, are divers heaps of earth to be seen, most of which are not above three foote in depth to the level of the earth, and some hardly so much, the distance of them from each other being in divers places not above four foote, and in some about six. They are many in number [300 at least as I ghesse] and of various biggness, being by the country people called 'Danes' Graves'; so that there is no doubt but that they did cover the bodies of such as were slain in wharre there. In other parts of the country are also here and there one, but of a much greater magnitude."

III. The following passage in Gibson Camden's Brittanico, published in 1695, page 738, probably alludes to "Danes' Graves": "Somewhat more eastwards the River Hull runs into the Humber; the rise of it is near a village called Driffield, remarkable for the monument of Alfred, the most learned King of the Northumbrians; and likewise for the many barrows raised hereabouts."

IV. The following is an extract from the Kilham Parish Register, 15th May, 1721:—"That on the day and year above said we, the Vicar and twenty horsemen, who were beating the bounds, began our perambulations on the west side of Pockthorpe, and in our procession we came nigh the Danes' Graves, in Driffield Field, where out of curiosity we caused a man to dig in one of the said graves. When digging, we found a large thigh bone, one leg bone, and one skull, of no extraordinary size, with several other bones.—Signed, Thomas Prickett, Vicar."

V. In a letter from Mr. Thomas Knowlton to Mr. Mark Catesby, F.R.S., concerning the situation of the ancient town Delgovicia, occurs the following note:—

"Londisburgh, Sept. 1745."

"Within a mile and a half of Kilham is a place called Danes' Graves, near which, it is supposed, was fought a great battle, in which infinite numbers fell; and so were laid in heaps and covered with the chalky soil in little tumuli, of the quantity of two or three square yards; in which, if opened, one may find great quantities of human bones, though, at this distance of time, I believe there is not less than an acre of ground covered over with them, joining close to each other; and it is one of the greatest curiosities of antiquity, in my opinion, I have ever seen; I am determined one day to go and number them, and to measure the quantity of land they cover."

VI. Mr. Allott, Rector of Kirkheaton, says:—"At a place called Kilham, near Bridlington or Burlington Bay, was a battle fought, and there are many tumuli or graves"; and asking some persons who were stubbing whins or gorse, they told him there was one under the whins, and several round about him. He says further, "that many are sunk level with the ground, but by what remains he supposes there were twenty thousand slain. "There are axe-heads, spears'-heads, etc., constantly dug up in opening them."*

"A stone is set up on high [at Rudstone] as a steeple, which no engines now used could raise. It is supposed to be set up by the Danes in a line between the field of battle and Burlington Hill, where their camp is yet to be seen very perfect."†

BRONZE ARMLET FROM DANES' GRAVES.

VII. Dr. Thurnham drew the attention of the meeting ‡ to a bronze Armilla (plate xli.) in the Ashmolean Museum, presented October, 1830, by the Rev. W. Drake, of Broomfield House, Northallerton, by whom it was exhumed from one of the remarkable group of barrows near Driffield, East Riding of Yorkshire, commonly known as the Danes' Graves. Mr. Drake stated that the skeleton in this barrow—which, like the rest, was of very small elevation—was lying with the feet to the east. Under the skull was a large stone described as of blue granite, and within it "the constituent parts of an iron comb." With the skeleton was the bronze Armilla here figured, and the fragments of another of highly-polished jet encircling the radius and ulna of the left arm. The fragments of jet were not preserved. The ornamentation of the Armilla found near Driffield is of a peculiar and rude kind, and is confined to the exterior, the inner surface being smooth and plain. The style assimilates somewhat to that of a gold armlet in the Copenhagen Museum, figured in Wasaæ's "Afbildninger," fig. 302.

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* Recent researches do not bear out the finding of axe-heads and spear-heads.—J.R.M.

† Thomas Bateman, "Ten Years' Diggings," p. 251.

‡ Archæological Journal, vol. xvi., p. 83.

VIII. Mr. John Browne, of Bridlington Quay, has favoured me with the following account:—"In 1834, Mr. John Milner, of Kilham, Dr. Andrew Allinson, and a party of others, opened one of the largest* of the tumuli in a group. After exploring some time without success they turned to the outer side, when they came upon a full-sized skeleton, which was complete, with the exception of the feet, which were wanting. (The pelvis gave indication of its being that of a female.) The vertebra seemed for the most part to be anculosed, and the femora and other bones showed it to be the skeleton of a female. In another tumulus a small Urn was turned up, but it was broken by the spade of the digger. It contained a quantity of fine black mould. Another of the skeletons turned up was also of large proportions. In the skull was a hole, which had undoubtedly been made during life; and on the leg bone was a cut from a sharp instrument, which appeared to have also been made during life. Various other "diggins" have been made by several other persons, especially by a man named Jesse Wood, of Langtoft. He possessed a considerable collection of articles which he found, but I am unable to say what became of them." †

IX. I give an account by W. Proctor, M.R.C.S., of the opening of six of these mounds by the Yorkshire Antiquarian Club, in 1849.

"Near the east edge of the "Yorkshire Chalk" Wolds, three miles north of Driffield, is a secluded spot of woody ground, measuring four acres, covered with tumuli of small size and slight elevation, so closely arranged as not to leave more than 3 ft. to 6 ft. between any two of them. The form is circular, with an average diameter of 18 ft., and an elevation from 2 ft. to 3 ft.

"In August, 1849, six of the tumuli were opened. Each was found to consist of the chalk of the district, mixed with a small proportion of earth. A few scattered nodules of the decomposed iron pyrites, which occur in the chalk, were also found. In the centre of the first tumulus was a skeleton, having the head to the north and the feet to the south; it was laid on the face, with the limbs doubled beneath the trunk;* the bones of the arms, forearms, and of the legs and thighs, were found side by side; the hands and face, elbows and knees, and the feet and hips being severally in contact. Close to the skull were the fragments of a vessel of rude earthenware about a pint in capacity. It is of a grey colour, and is composed of clay with numerous fragments of chalk and calcareous spar. It is of cylindrical form, widening towards the mouth, with a projecting rim at the bottom. It had been imperfectly baked, and probably made on the wheel.† In No. 2 was a skeleton laid in the same position and direction as the preceding skeleton.

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* Probably this is No. 11 of the mounds opened in July, 1897, and described in Part 2, later on.—J.R.M.

† Probably some of these may yet be in existence.

"Close to the skull was a broken Urn of the same general character and composition as the former example, except being of a black colour and very fragile. Its shape seems to have been somewhat globular. On opening No. 3, a skeleton only was found in the same contracted position, with the head to the south-west, and the feet to the north north-east, lying on the left side with the face to the west.

"In the fourth tumulus a skeleton was discovered, placed in a directly opposite position to No. 3, viz., with the head to the north north-west, and facing the west. A second skeleton lying in the same contracted position on the right side, with the head to the north and face to the west, was met with. Besides a piece of iron, much corroded, of a flat and semi-circular form, beneath the body, no other remains were seen. The sixth barrow was a large one,‡ 5 ft. high and 25 ft. in diameter.

"After a most careful examination no vestige of interment or other deposit could be found."§

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* This is also a mode of burial occasionally observed in the more ancient British tumuli.

† More probably not.—J.R.M.

‡ This might be No. 13 of the mounds opened in July, 1897, and the one in which the Chariot was found.—J.R.M.

§ The Proceedings of the Yorkshire Antiquarian Club, 1854.

X. On April 2nd, 1894, Mr. Thomas Dowson, of Pickering, informed me that he accompanied the late Mr. Thomas Kendal, of Pickering, to "Danes' Graves" in 1849 or '50, and that they then opened three of the mounds. In each they found a body, accompanied by pieces of rusted iron; but he did not remember anything else having been found, and Mr. Kendal seems to have kept no record.

My first visit to these graves was in 1860, and I found in the hedge bottom near the mounds a rudely-formed top-stone of a hand-mill. On the grinding face of this stone are a series of concentric lines scratched into it, reaching from the centre to the circumference; whilst the two oval holes for inserting the handles have been punched or picked into the stone, *not* drilled into it, as are the holes in all the other mill-stones I possess.

XI. The following and most complete account is by Canon Greenwell, in the Archæological Journal, vol. xxii., which I beg permission to repeat.

"The barrows next examined [B] lie a little beyond the district which we have been considering.

"They are found in a hollow in the chalk hills of the Wolds, about four miles north of Driffield. They are called the "Danes' Graves," and number nearly 200,* lying close together in a wood. Several were opened a few years ago by the Yorkshire Antiquarian Society [Club], but the greater number have been destroyed in digging for rabbits. I examined fourteen of these barrows on March 27th and 28th, 1864. They are all small, from 16 ft. to 24 ft. in diameter, and from 2 ft. to 4 ft. in height, and are formed of chalk rubble, the material at hand. The interment, in every one which I examined, as I believe was the case in those previously opened, was contained in an oblong hollow made in the natural surface, and the bodies appear to have been laid therein without coffins.

"As all the interments were, except in some unimportant particulars, similar, I will give the general character of the burial, noting separately those which presented any exceptional features. The bodies were doubled up, so as to suggest that they must have been tightly swathed, in order to bring them into the required shape; the hands were placed upon the chin, the bodies were laid, some on the left side, some on the right;* of those which were sufficiently perfect to determine this, six were on the left and five on the right side; and whilst seven had the head to the north, or to the west or east of north, two had the head to the south-west, one to the west, and one to the east. In one instance two bodies were interred in the same barrow; the first—that of a child about five years old— just below the summit of the mound; the second—that of an old person, and judging from the imperfect pelvic bones, most probably a male—in the usual hollow made in the natural surface of the ground. In three of the graves an Urn had been placed close behind the head; these Urns, however, were so much decayed that the shape can scarcely be ascertained. They are quite plain, pale, gray-coloured on the exterior, but of a dark-coloured ware in the middle, full of small pieces of stone. These Urns are well formed by the hand, with the lip slightly turned over, and they measure a little under 5 in. in height. The most remarkable interment [C] was that of a man laid upon his right side, with his head to the west; lying close to the mouth—so close that some of the teeth are discoloured by the oxidation of the metal—was a piece of iron, too much corroded to assign any certain use to it [see woodcut, fig. 1, half original size].† On each side of the man were placed two goats, their heads, like his, to the west. The occurrence of a goat with an interment is exceedingly rare; we have numerous instances where a horse, ox, deer, boar, or dog has been buried with a man, but except this at Danesdale, I have only known of two other cases where a goat has been found associated with a burial.‡ In the almost entire absence of weapons or implements

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* Before the Wolds were enclosed a great many more existed; it is stated that there were, originally, as many as 500.

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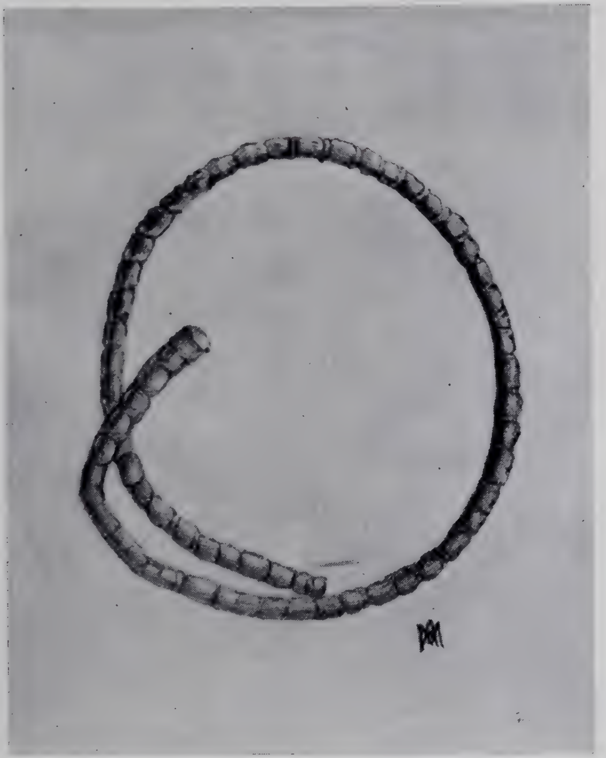
* Of five bodies discovered, when the examination by the Yorkshire Antiquarian Club took place, two had been laid upon the face.

† See Canon Greenwell's paper in the Archæological Journal, vol. xxii.

‡ In a barrow six miles north of Pickering was a cist, in which was found a skeleton, where, along with several flints, was deposited near the head of the man a head of a goat. Bateman's "Ten Years," Diggings, p. 223. At



BRONZE ARMLET, FOUND IN THE "DANES' GRAVES."

Proc. Yorksh. Geol. and Polytec. Soc., Vol. xiii., Plate xli.

in these barrows it is difficult to arrive at any conclusion as to the period of their erection, or the people by whom they were made. The name "Dane's Graves" cannot, I think, be taken as proof of their Danish origin, for that designation has been frequently applied to camps, lines of entrenchment, and barrows,* which have certainly no connection with that people. The cruelties practised by the Danes seem to have made so strong an impression, that the people who suffered by them appear, sometimes, to have called certain works of unknown origin after the names of their oppressors, just as similar remains are named after the Devil. At the same time, some weight must be allowed to the popular tradition, and if nothing about the grave-hills is inconsistent with a Scandinavian origin, it is only fair to admit the probability of their being the burial mounds of some Danish settlers."†

Canon Greenwell adds:—"My own opinion is against the Scandinavian origin. The mode of interment is unlike any which has been found in Denmark, Norway, or Sweden; I do not make this assertion upon my own authority, but on that of Mr. C. F. Herbst, of Copenhagen, the Scandinavian archæologist, to whom my notes of these barrows were submitted. The pottery, also, is not such as is found in Danish grave-mounds, either in shape or fabric. On the other hand, if we attribute these mounds to a tribe of kindred origin with those who buried under the ordinary round barrows, we are met by more than one difficulty. The bodies in the 'Danes' Graves' had been interred in a much more contracted position than is usual in the British burials. The great number of these barrows, and their close grouping are also peculiar features; for though two or more 'British' grave-hills are frequently found

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Therfield, near Boyston, with the remains of other animals, were found in a barrow two crania, which Prof. Duckett considered to be those of goats. Proc. of the Society of Antiquaries, 2nd series, vol. i., p. 306.—CANON GREENWELL.

* The "Danes' Hills," near Skipwith, in the East Riding, are barrows which contain interments of burnt bodies having nothing in common with what we know of Danish interments.—CANON GREENWELL.

† The burials are those of a settled population and not of any mere invaders. This is indicated by the number of the barrows, and the frequency of the interments of women, as well as that of a child.—CANON GREENWELL.

together, they are never massed like graves in a churchyard, as at the 'Danes' Graves.' The crania, as will be seen from Dr. Thurnam's account on the next page [which gives an average breadth-index of ·73] are not of the Brachycephalic type, so distinctive of those found in the round barrows and stone cists, but approach nearer to the long Scandinavian type; a fact of great importance, when the number of skulls examined is considered.

"The pottery is neither in shape nor colour like that of which so many specimens are described in this memoir [referring to 'Ancient British Pottery'] and it also differs from it in the absence of ornamentation; but it is still more unlike Scandinavian or Anglo-Saxon ware. The presence of iron indicates a comparatively late period; but the nature of the objects found, whether of iron or bronze, give little, if any, clue to the origin of these barrows. I, therefore, prefer, in the absence of any distinctive data, to offer no conjecture as to the people to whom these burials belong, nor do I think that further examination would add much information to that which we already possess." Thus concludes Canon Greenwell's report.

Not concurring with the Canon's closing remarks, and believing that a further careful search, in some of the few mounds which have not yet been disturbed, would now greatly aid us in adding something more to the very little we at present know of this very interesting and extensive group of barrows, I wrote to W. H. Harrison Broadley, Esq., M.P., asking permission to open two or three of them, thinking that probably it would enable us to make out approximately the period when the mounds were raised, and also something more of the small community which must have been, as suggested by Canon Greenwell, in quiet possession of the neighbourhood for a considerable time. I regret to say that I received the following reply:—

"Welton, Brough, Feb. 6th, 1871."

"Sir,—I am very sorry indeed that I cannot comply with the request you have made, for these reasons. First, the 'Danes' Graves' on Mr. Allanson's farm at Danesdale, and also on Mr. Gofton's at Pockthorpe, if there are any there, have been so frequently and so thoroughly examined that there can be nothing

No.	DERIVATION OF SKULL.	Probable		I.	II.	III.	IV.	V.	VI.	VII.	A	B
									Face.		Breadth. Length. =1·00.	Height. Length. =1·00.
		Sex.	Age.	Cubic Capacity.	Circumference.	Length.	Breadth.	Height.	Length.	Breadth.		
	1864.											
1	Danes' Graves No. 2	M.	40	101	20·6	7·4	5·25p	5·7	4·4	5·1	·70	·77
2	,, ,, ,, 6	M.	60	97	21·1	7·5	5·6p	5·8	—	—	·75	·77
3	,, ,, ,, 8	F.	45	82	19·9	6·9	5·5p	5·4	—	—	·79	·78
4	,, ,, ,, 9	F.	5	78	18·0	6·5	4·8p	5·4	3·0	—	·73	·83
5	,, ,, ,, 10	F.	45	86	19·7	7·2	5·1p	5·6	4·4	—	·70	·77
6	,, ,, ,, 11	M.	40	94	20·3	7·25	5·2p	5·4	4·4	5·0	·71	·74
	1849.											
7	Danes' Graves No. 1	F.	—	—	20	7·2	5·3p	5·8	—	—	·73	·80
8	,, ,, ,, 2	F.	—	88	20	7·2	5·2p	5·4	—	—	·72	·75
9	,, ,, ,, 3	F.	40	86·5	20	7·2	5·2p	5·6	4·3	—	·72	·77
10	,, ,, ,, 4	M.	35	85·5	19·7	7·2	5·4p	5·6	4·1	4·6	·75	—
11	,, ,, ,, 5	M.	45	91·5	20·2	7·2	5·5p	5·4	4·6	—	·76	—
	Average of 5 skulls of men ...			94	20·5	7·3	5·4	5·6	4·4	4·9	·73	·77
	Average of 5 skulls of women ...			85·5	19·9	7·1	5·2	5·5	4·35	—	·73	·77

NOTE.—This table is copied from the Archæological Journal, vol. xxii., p. 264, and is a summary of the measurable skulls obtained by Canon Greenwell up to 1864, and those obtained by the Yorkshire Antiquarian Club up to 1849.—J.R.M.

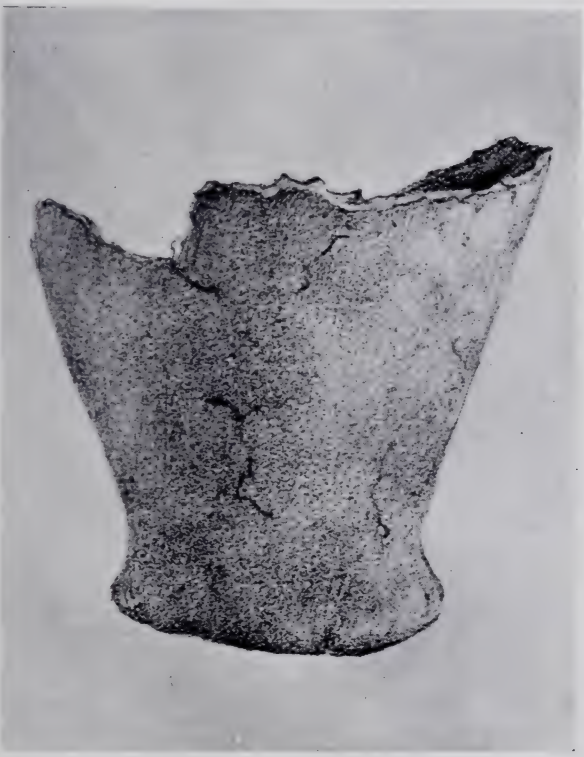
left to discover; and, secondly, I am obliged to say that the investigations have been conducted so recklessly, so carelessly, and even so indecently—the graves were not even filled up again—that I have determined not to again allow them to be disturbed. In the Museum at York you will find various articles that have been found. I myself do not possess one, they have all been taken away, or I would send them for your inspection, if you wished it.

"Believe me to be,
"Yours faithfully,
"W. H. HARRISON-BROADLEY."

Though the hacked appearance of the mounds showed much cause for Mr. Broadley's complaint, I was sorry not to be permitted to make further search. However, since then, natural causes have given me some assistance.

On October 20th, 1881, the late Mr. Henry Kingston, who occupied the farm nearest to "Danes' Graves," informed me that the high wind of the previous Friday had uprooted a large quantity of trees in the "Danes' Graves" Plantation; some of which had torn up the ground sufficiently to expose interments. On the following day [the 21st October], in company with Dr. Wood, of Driffield, I visited the place and its surroundings, and we observed that a double line of British entrenchments ran along the northern margin, extending for miles both in an eastern and a western direction from the graves. We also noticed that the southern side of the hollow "Danesdale" which the graves occupy was covered with an accumulation of un-water-worn chalk gravel, which gravel does not extend to the opposite side of the dale.

The uprooting of the trees was mainly confined to the gravelly area; those growing on the chalk rock on the north side of the dale having for the most part resisted the violence of the wind. The first exposure which had attracted Mr. Kingston's notice was a calvarium pulled up by the roots of a tree which had grown on the apex of one of the mounds. Through the kindness of Mr. Kingston I possess this calvarium. It is long and narrow, with a breadth-index of ·69, and altogether of small size, and apparently belonged to a female.



FOOD VASE, FOUND IN THE "DANES' GRAVES."

Proc. Yorksh. Geol. and Polytec. Soc., Vol. xiii., Plate xlii.

The broken long bones were also small. The barrow which covered this interment was not more than 15 ft. in diameter and 24 in. high; and the body seemed to have been placed a very little below its base. On the following Wednesday [October 26th] I employed an experienced digger, who, with the assistance of Mr. Kingston, junior, carefully explored the ground whence the calvarium had come, but as most of the long bones had been removed, the position of the interment could not be made out; no relic was found.

The uprooting of another tree had, however, exposed the feet of a second body. Here also we carefully examined the ground beneath, and were able, fortunately, to make out its position.

This body was also near the centre of a small mound about the size of the last, and not more than 3½ ft. deep from the top of the mound. It lay on its left side, leg much pulled up, left arm down by the side with hand on pelvis, the right arm was over the body with hand on left arm. Its head was to the west. Near the right leg were the humerus of a small pig, or goat, and portions of a crushed food vase, which also had a splayed bottom (plate xlii.), other portions of which lay near the right arm, and seemed to have been removed by rabbits burrowing in the mound. Otherwise, the body was undisturbed and in fairly sound condition. The skull, which was crushed, has been put up, and seems to be that of a male of about 35 years of age, with a cephalic-index also of ·69. The forehead is low and the superciliary ridges well developed. The femur measures ·17¼, tibia ·14¼, and the humerus ·12¼, and they are of rather slender substance. Eleven other crania from these graves [obtained by the Yorkshire Antiquarian Club and by Canon Greenwell] give an average breadth-index of about ·73*, which shows them to belong to a decidedly long-headed type. The vase—the upper part of which is wanting—is hand-made, quite plain, of a coarse, dark texture throughout, containing particles of pounded quartz and flint, and has been tolerably well baked. It has a broad, flat, and very thin bottom, and is very unlike any I have ever found with a true British interment in the large barrows on the Wolds. It rather resembles a rude kind of dark Roman, or Romano-British vessel than any other kind with which I am acquainted. No other relic was found.

It is to be deeply regretted that more is not known of this extensive and almost unique group of barrows, and the distinctly-marked community of men [as shown by the crania] who raised them.

The plantation, which now protects the mounds, is an old one, and the trees of which it consists are likely, before long, to be cut down, and the mounds left to the mercy of the plough; a little time will then suffice to remove all trace of their whereabouts, and make research almost impossible. Before this happens a further examination, conducted under experienced supervision, is most desirable; indeed, it is an imperative duty demanded by archæology.

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* See the Journal of the Archæological Institute, vol. xxii., p. 264.

NOTES ON THE DANES' GRAVES NEAR DRIFFIELD.

BY THE REV. E. MAULE COLE, M.A., F.G.S.

The collection of tumuli, known as Danes' Graves, occur on the Wolds, at the junction of three parishes—Great Driffield, Nafferton, and Kilham. They are actually in the parish of Great Driffield, though in some reports they are described as being in the parish of Kilham. They are situated immediately to the south of a line of entrenchments which, roughly speaking, extends from Flamborough Head to Garrowby Hill top. This line of entrenchments is remarkable for the fact that it forms the boundaries of all parishes from York to Flamborough. It is more or less sinuous, and, in all probability, marks the track of an ancient British way from Eburac (our modern York) to the coast. It may have been utilized by the Romans after their conquest of the country, as there is evidence (obtained by my friend, Mr. J. R. Mortimer) of a Roman-British cemetery on both sides of the road, in the parish of Wetwang-with-Fimber, but I think that the Romans constructed another road in the rear, at a higher elevation, from Fridaythorpe, through Sledmere and Octon to Bridlington Bay, known as the High Street. The site of Pretorium, mentioned in the itinerary of Antonine, has long been a matter of dispute, and is so still, but when it is considered that the Romans would probably wish to have access by sea to such an important place as Eburacum, then the capital of Britannia, it is not improbable that they would select the shortest land route, to which an ancient British way already pointed. The destruction of the boulder-clay cliffs to the south of Flamborough Head, which, since the Roman occupation, has resulted in a loss of some two miles of coast-line, will account for the fact that we are unable to point out the site of the lost Pretorium. Like some antiquaries, with little knowledge of the district, it is "all at sea."

One thing is almost certain—which I have often insisted on in various papers—that the Romans would never dream of rounding the terrible headland of Flamborough, Buckton, and Bempton, to land in Filey Bay, when they could find a commodious and safe shelter in that of Bridlington.

To revert, however, to the so-called Danes' Graves. They are actually contiguous to the ancient British way above alluded to, all on the south side of it. On the Ordnance Map they are shown as closely grouped together as cobbles in a pavement, to the number of 197, but their number must have been far greater before the land was disturbed by ploughing, as the adjacent fields show the remains of many others which have been levelled down. In all probability 400 or 500 graves were once as well visible as those now to be seen. Similar groups of graves are (or were) to be seen at Arras, and at Scorborough, both in the East Riding. This special grouping is utterly unlike anything to be met with on the Wolds, though Mr. Mortimer for the elucidation of his excellent collection from barrows on the Wolds, has grouped together certain tumuli, and has founded thereon a star theory, which, unfortunately, I am not able to agree with. The peculiar grouping of the graves at Danes' Graves, and the other places mentioned, points to a *settled occupation.* No battlefield would account for so many separate graves. We must rather look upon them as an ancient cemetery of a settled population.

When we come to look at the contents, which will be fully described in a future paper by Mr. Mortimer, we shall find that they are quite different from the mass of tumuli on the Yorkshire Wolds, and of a much later date. In the earlier tumuli there is very little trace of bronze, and none whatever of iron. Out of 300 tumuli on the Wolds, examined by Mr. Mortimer, only about 12 showed any trace of bronze, which was comparatively unknown when they were located. Hence we must assign the earlier mounds partly to the Stone Age and partly an early period in the Bronze Age. The knives, celts, saws, and other instruments as arrowheads and spears, are all of flint or stone. The bodies were mostly inhumed, not cremated; later on, as authorities tell us, bodies in the Bronze Age were mostly cremated. Both kinds of interment, however, occur in the same mounds on the Wolds.

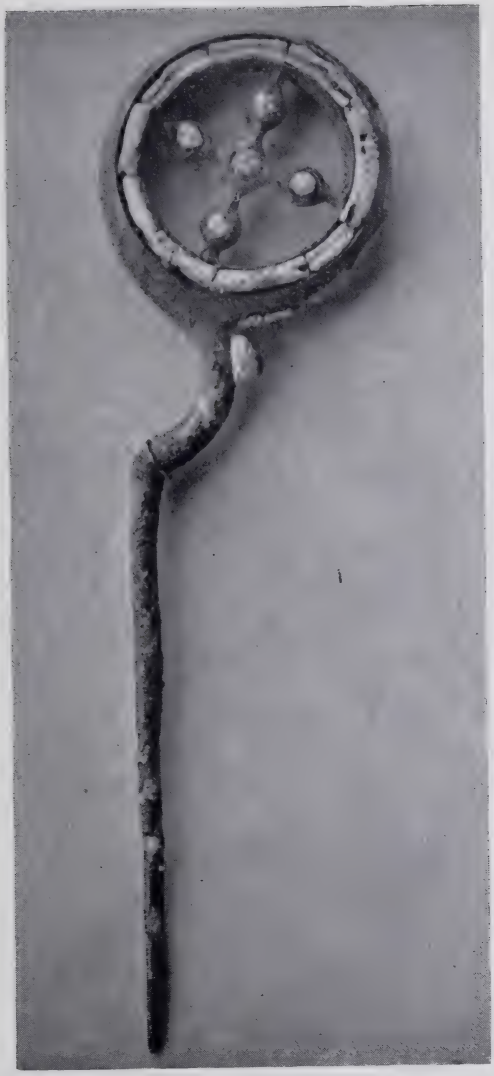

Photo. M. Boak & Sons, Driffield.

BRONZE ENAMELLED HAIRPIN.

Proc. Yorksh. Geol. and Polytec. Soc., Vol. xiii., Plate xliii.

This year, 1897, Mr. Mortimer fortunately obtained permission from Mr. Harrison-Broadley, the owner of the soil, to make an examination of the Danes' Graves. Some twelve or more mounds were opened by experienced workmen. The result was highly satisfactory. In one grave a beautiful enamelled bronze pin was unearthed (plate xliii.), characteristic of the late Bronze Age; in another, two chariot wheel tyres of iron, with iron bits, and bronze trappings for the horses. Such remains of British charioteers have, as far as I know, only been found in the East Riding of Yorkshire, and those at Arras.* The date may be assigned to 100 years before or after the Christian era.

This discovery does away with the popular nomenclature *Danes'* Graves. The mounds situated in Danesdale are not those of Danes at all. They are far more ancient than the incursion of the Danes, or Vikings, on the East coast of Yorkshire, which occurred in the 8th or 9th century. Like the Danes' Dike at Flamborough, which was carefully examined and tested by Major-Gen. Pitt-Rivers in 1879, and proved by him to have been the work of men using flint weapons only, the name of Danes' Graves has simply been preserved in popular tradition because the Danes were the last dread marauders who ravaged the East coast, and destroyed hamlets and churches alike. Doubtless the formidable Dike which runs from end to end across the promontory of Flamborough, was utilized by the Danes, as it was by the Romans before them, but it was thrown up by an earlier people using flint weapons, and so with the graves in Danesdale. They are the remains of a race existing in almost prehistoric times, and if I might venture to offer a suggestion I think it not unlikely that they represent a burial place of the Parisi, who, as distinguished from the Brigantes, are said to have occupied Holderness.

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*A chariot wheel was found by Mr. Kendal on the moors, N. R.

THE HALIFAX COAL STRATA.

BY JAMES SPENCER.

(*Read October 7th*, 1897.)

The Yorkshire coal field is divided into three horizons, viz., Lower, Middle, and Upper.

The Lower Coal-Measures appear to have first been worked at Halifax, and thence the mines were gradually extended around the out-crop of the coal-field, and the two workable beds of coal wrought in them became known as the "Halifax Hard and Soft Bed coals."

The Halifax coal strata form a compact group of rocks, consisting of beds of shale, sandstone, rag, bind, coal, seat-earth, gannister, ironstone and fossiliferous beds of marine and freshwater origin, the whole being enclosed between the Rough Rock at the base and crowned by the Northowram and Elland Flagrock. These strata are also well known to geologists on account of the great number and variety of their fossil contents. The marine beds overlying the Hard Bed coal have yielded a large number of marine fossil shells and fish-remains to our local collectors, and more recently the rich and various assortment of Fossil Plants shewing their internal structure found in our coal-balls, have extended the fame of our Halifax Coal strata over the civilized world.

The conditions attending the formation of the different beds were of a very varied character, and the area in which they were deposited was sometimes a land surface, covered by extensive forests of lepidodendrons, sigillarias, calamites, cycads and ferns in great variety; at others a great estuary inhabited by molluscs and fishes, and into which the rivers of the period brought down spoils from the ancient land, such as sand and mud, trunks and branches of trees, etc., and into which the sea occasionally erupted and brought into the area marine shells and fishes.

The fact that the Coal-Measures were deposited in a gradually-sinking area is generally admitted by geologists, and it has been suggested that the subsidence was probably caused by the immense weight of materials brought into the area, pressing down the yielding crust of the earth; occasionally pauses in the subsidence took place, followed by slight elevations into land surfaces.

TABLE OF THE HALIFAX COAL STRATA.

1.	Flagrock of Northowram and Elland		70 ft. to 150 ft.
2.	Shales and Raggystone		100 ft. to 150 ft.
3.	80 yds. Band Coal and Seat-earth		2 ft. 3 in.
4.	Strata, including 60 yds. Band Stone and "Quarrel" Rock		100 ft.
5.	48 yds. Band Coal		8 in.
6.	48 yds. Band Stone		6 ft. to 12 ft.
7.	Shales		28 ft.
8.	36 yds. Band Coal		8 in.
9.	Shales and Bind and 36 yds. Rock		98 ft.
10.	Shales with "Baum pots" and Marine Shells, Goniatites, Nautili, Aviculopectens, &c.		9 ft.
11.	Pecten Bed, Aviculopectens, &c.		6 in.
12.	Hard Bed Coal, with Coal Balls		2 ft. 3 in.
13.	Gannister Rock and Seat-earth		4 ft.
14.	Shales		28 ft.
15.	Middle Band Coal	10 in.	3 ft. 10 in.
	,, ,, Seat-earth	2 ft. to 3 ft.	
16.	,, ,, Stone		about 3 ft. to 5 ft.
17.	Shales, containing beds of Anthracosia and Spirorbis		30 ft. to 40 ft.
18.	Soft Bed Coal	1 ft. 4 in.	3 ft. 4 in.
	Seat-earth	2 ft. 0 in.	
19.	Low Bed Stone (Soft Bed Flags)		12 ft. to 20 ft.
20.	Shales		40 ft. to 50 ft.
21.	Thin Coal		3 in. to 8 in.
	Seat-earth		4 ft. to 6 ft.
	Rough Rock.		

The total thickness of the above series is in this district about 600 ft.

The outcrop of these beds forms a very striking feature in the physiography of our neighbourhood, ranging from Swill Hill (1,300 ft.) on the north, round by Ringby Hill (1,100 ft.), Beacon Hill (850 ft.), and Sowthowram on the east; standing from 500 ft. to 600 ft. above the Millstone Grit Rock at their base, they form a bold escarpment facing the west.

The great estuary in which these rocks were deposited was covered towards the close of the Millstone Grit period with a wide extent of sand-banks which rose above the level of the waters, but were intersected by numerous water-channels. Then subsidence of the area took place and the sand-banks were levelled and the channels filled up, thus producing that well-known feature of false-bedding so characteristic of the Rough Rock. Then the whole area was covered with a deposit of clayey mud (seat-earth) and upraised into a land surface, which subsequently became covered with the greenery which ultimately was converted into the thin coal now found overlying the Rough Rock. This is the lowest seam of coal in the Yorkshire coal-field. We have seen this coal exposed in many places in this district. It varies from 4 in. to 8 in. in thickness, but near Elland, where it was formerly worked, it was 2 ft. 4 in. in thickness.*

The whole area again sank beneath the sea-level, and to the south of this district the sea invaded the area, and has left evidences of its sojourn in a bed of marine shells — Goniatites, Aviculopectens, &c., but these fossils have not been recorded from the Halifax district at this horizon. From 40 ft. to 50 ft. of shales overlie this Sand Rock Coal followed by 20 ft. of the Low Bed Stone = Soft Bed Flags, of the Huddersfield district. Then a bed of seat-earth was deposited and a land surface was again formed, upon which was produced the vegetation which formed the Soft Bed Coal. Once more the land sunk beneath the waters of an estuary in which myriads of freshwater mussels (Anthracosia) and Spirorbis flourished, which have left their remains in beds of from 4 ft. to 12 ft. in thickness. Two species of these shells, viz., *A. robusta* and *S. carbonarius* have a world-wide distribution, and occur more or less in most of the shale beds from the top to the bottom of the Coal-Measures. Sometimes the small Spirorbis flourished in such incalculable numbers as to form beds of from 1 yd. to 6 yds. in thickness of impure limestone. Anthracosia and Spirorbis are characteristic Coal-Measure fossils, and the latter has been frequently found attached to the stems of fossil plants and the fronds of ferns.

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* Geology of Dewsbury, Huddersfield, and Halifax, p. 5.

The Anthracosia were at first called Unios from their resemblance to those of the recent genus Unio. But afterwards, on account of their being often found in the *débris* on our coal-pit banks, along with Goniatites and other marine shells, it became doubtful as so whether they were of freshwater or of marine origin, and so they were given the name of Anthracosia, which simply means "Coal-Measure Shells."

In Yorkshire we have never had any doubt upon the point, having always regarded them as being of freshwater or of estuarine origin, and not long ago, my old friend, Mr. George Wild, one of the best practical geologists in Lancashire, informed me that the point had been clearly settled for that county, viz., that Anthracosia do not occur *in situ* in the same beds as the marine shells, and that there is now no reason for doubting their being of freshwater origin. *Spirorbis carbonarius* appears also to have been a freshwater species belonging to the Annelid family which, at the present day, is well represented by marine species infesting the sea-weed on our coasts.

After about 30 ft. to 40 ft. of shale had been deposited, a bed of fine gritty sand was formed (Middle Band Stone) of from 3 ft. to 5 ft. in thickness, which is now one of the hardest rocks in the whole group. This was covered by a bed of seat-earth, then the area became a land surface, and the vegetation which formed the Middle Band Coal was produced. Afterwards the land once more subsided beneath the waters and about 30 ft. of shales were deposited upon the coal, followed by 4 ft. to 6 ft. of seat-earth and Gannister Rock. This gannister is a hard, fine-grained silicious rock, full of Stigmarian rootlets, and occurs in the midst of the seat-earth. It is one of the most characteristic rocks in the Carboniferous formation, and is closely allied to the Galliard Rock of the Millstone Grit series.

Afterwards the whole area rose above the water, and a land surface was formed which probably endured for hundreds of years, and was covered by vast forests of Carboniferous trees and ferns, which ultimately became converted into the Hard Bed coal. The magnificent flora of this epoch, fortunately for science, has been well preserved in our coal-balls, which occur in this seam. The fossil plants found in these coal-balls, have their internal structure perfectly preserved. The balls contain fragments of lepidodendron in great abundance and variety, sigillaria, stigmaria, calamites, cycads, tree ferns and other ferns in great numbers; also spores, fruits, nuts, seeds, etc., all shewing their internal structure under the microscope. Perhaps one of the most interesting discoveries made in connection with these coal-balls, was the finding of fossil fungi in the interior of many of the fossil plants, and in a splendid state of preservation.

Marine Strata Overlying the Hard Bed Coals.

After the growth of the vegetation which produced this coal, the physiography of the whole area changed from a land surface with a magnificent flora to a deep sea, but no great disturbance of the strata took place, for immediately overlying the coal is a bed of marine shells (Aviculopecten) of from 3 in. to 6 in. in thickness, which appears to be co-extensive with the coal. There are several species of Aviculopecten and also a few other shells, but the great majority belong to the species *Aviculopecten papyraceous.* Overlying the pecten bed there are from 3 ft. to 9 ft. of shales, containing a large number of roundish concretions locally called "Baum Pots," which are composed of black limestone and coated with iron pyrites. They are interesting to the geologist on account of their containing *Goniatites listeri* in great profusion and of all sizes, from $\frac{1}{16}$ of an inch or less to 2 in. or 3 in. in diameter, together with a large number of other fossil shells and fish-remains. Large specimens of *G. listeri*, Orthoceras, Nautili, &c., and also occur in the shales free, *i.e.*, not enclosed in nodules.

The following list comprises most of the species found in these marine strata in the neighbourhood of Halifax:—

Goniatites listeri (Martin).
„ *evolutus* (Phil).
„ *looneyi* (Phil).
„ *calyx* (Phil).
„ *mutabilis* (Phil).
Nautilus rawsoni (Englis).
„ *sphæricus* (Phil).
„ *nodosus?*
„ *endosiphonus* (Phil).
Orthroceras steinhaueri (Phil).
„ *cinctum* (Phil).
„ *fusiforme* (Phil).
„ *attenuatus.*
Bellerophon urii (Phil).
„ *tenifuscia.*
„ *decussatus.*
Aviculopecten papyraceous.
Modiola lingualis (Phil).
Lingula paralella (Phil).
Malanea imbricatum (Phil).
Nucula tumida (Phil).
„ *luciniformis* (Phil).
Venus paralella (Phil).
Posidonomya. Several forms.

FISH-REMAINS.*

Elonichthys striolatus (Traquair).
„ *aitkeni* (Traquair).
Megalichthys hibbertii.
Cœlacanthus phillipsii (Ag.).
„ *elegans* (Newbury).
Hoplonchus elegans? (Davis).
Strepsodus sauroides (Binney).
Acanthodes wardi? Spines.
Pœsilodus, teeth (Ag.).

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* The List of Fish-Remains was kindly revised by Dr. Wellburn, of Sowerby Bridge.

Overlying these marine beds there are about 98 ft. of shales and hard bind, the latter consisting of thin layers of shale and sand forming a very hard rock, and towards the top, merging into the 36-yards Band Rock, which, although seldom absent, is of varying thickness, from a few feet to as many yards. Upon this rock lies the 36-yards coal, from 8 in. to 10 in. in thickness, having under it a bed of seat-earth of from 3 ft. to 5 ft. in thickness. This seat-earth forms one of the best fireclays in our district and is extensively worked.

Overlying this coal are 10 yds. of shales and then the 48-yards Rock, seat-earth, and coal. This rock is of variable thickness, and sometimes is absent.

Between the 36-yards Band Coal and the 80-yards Band Coal, the strata are very irregular, consisting of shales with lenticular beds of sandstone. About Sheffield one of these is known as the Wharncliffe Rock, and at Wharncliffe Edge it is a coarse-grained massive grit of great thickness; northwards it thins out and becomes a softer rock, as at Halifax, with the quality of Gannister. At Bradshaw, near Halifax, a rock known under the name of "Quarrel" comes in and increases in thickness to the north-east, and is worked in the neighbourhood of Thornton.

The 48-yards Coal extends from Elland to Catherine Slack, and dies away to the north. It was formerly worked at Nab End, Boothtown, Halifax, where it was from 10 in. to 14 in. in thickness. The author can also recollect its being worked under the hill above Scout Hall, in Shibdendale, where it was about a foot thick, and was used as a house coal. The 80-yards Band Coal, although so thin (from 4 in. to 2 in. in thickness), is generally represented in the neighbourhood of Halifax and Huddersfield by either the coal or its seat-earth. The 80-yards Band Rock is only a few feet in thickness and not always present. About 125 ft. of shales overlie the 80-yards Coal, and upon these rest the Flagstone Rock of Ringby Hill (Elland Flagrock), here about 70 ft. thick. The rock is very largely quarried on this hill and at Northowram, and is of fairly good quality, both for flags, building stones, and ashlar.

This rock is evidently the shore deposit of a great estuary. It consists of alternations of beds of stone, rag, and shale, the rock having two beds of shale, one a foot and the other 5 ft. in thickness, which, further south, increase to 20 ft. or more in thickness—with a thin bed of Anthracosia towards the top. A great number and variety of fossil plants have been found in this rock, including Lepidodendra, Sigillaria, Stigmaria, Calamites, Halonia, Artisia, Cordaites, Bothrodendron, Trigonocarpons, Cardiocarpons, ferns, fruits, etc., worm tracks, and other curious trails.

FAULTS.—The Halifax beds, like most other coal strata, are dislocated here and there by faults which range from 52 yds. down to a few feet of throw; there are none, however, which call for any particular notice.

Fossil plants found in the Halifax Coal Strata and the Northowram (Elland) Flagrock:—

Calamariæ (Calamites) Suckow. Flagrock.
Calamitina varians (Sternberg). „
„ *göppertii* Ett. Flagrock.
„ *varians* var. (Schützei.). Flagrock.
Eucalamites ramosus. Artis. sp. „
Stylocalamites suckowii. Brougt. „
„ *cannæformis.* Flagrock.
„ *cistii* Brougt. sp. Flagrock.
Astrocalamites scrobicularis. „
Lepidodendron elegans. Soft Bed Coal roof, Southowram.
„ *sternbergii.* „ „ „
„ *peachii.* „ „ „
„ *dichotomum.* Hard Bed Coal-balls „
„ *selaginoides.* „ „ „
„ *gracilis* (Carr). Flagrock, Northowram.
„ *obovatum* (Sternb.). „ „
Lepidophyllum. Several forms. Coal Strata. „
Knorria taxina (decortated Lepidodendron). „
Halonia regularis—fruiting branches of Lepidodendron, Lepidophloios, and Sigillaria, Northowram.

Lepidophloios laricinus. Hard Bed Coal.
Lepidostrobus variabilis. ,, ,,
,, *geinitzii* (Schimper). Soft Bed Coal.
Sigillaria tessellata Hard Bed Coal, etc.
,, *organum.* Common.
,, *elegans.* Soft Bed Coal roof, Southowram.
,, *mamillaris.* Hard Bed Coal.
,, *reniformis.* ,, ,,
Stigmaria ficoides. Common.
,, *reticulata* (Kidston). Coal-balls.
Bothrodendron minutifolium. ,,
,, *punctatum.* Flagrock and Coal-balls.
Artisia transversa. Flagrock.
Dadoxylon. Large Casts. Flagrock.
,, *sternbergia* = *Artisia transversa.* Baum pot, shewing structure.
Trigonocarpons (casts). Flagrock, and many other forms of stone fruits.
Cordaites principalis. Flagrock.
,, (leaves). Coal-balls.

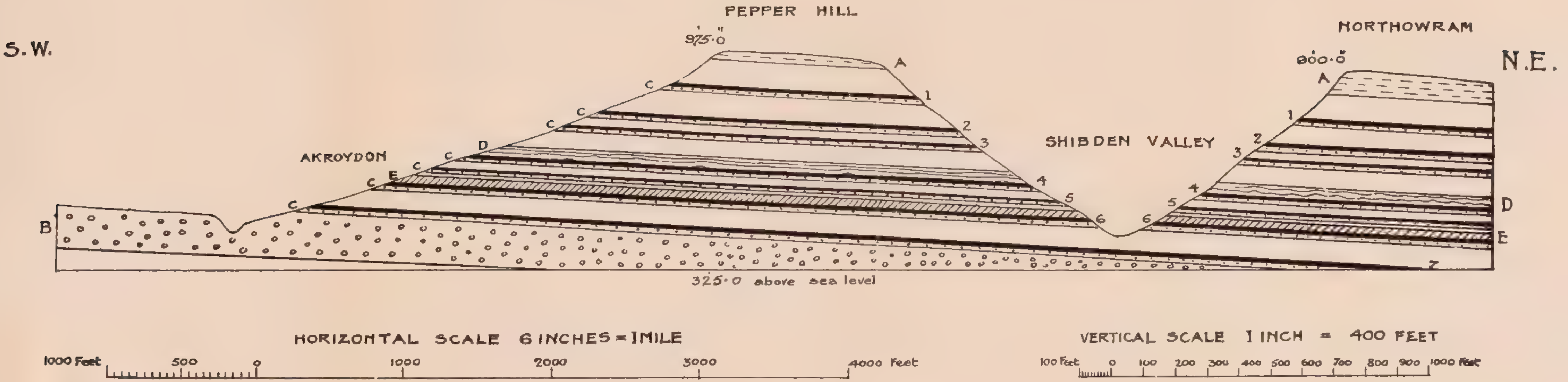
Fossil ferns are fairly common, but are seldom found sufficiently preserved for specific distinction. The four common genera have been found in these strata:—*Pecopteris*, *Alethopteris*, *Sphenopteris*, and *Neuropteris.*

The fossils herein mentioned, from the Hard Bed Coal-balls, are ordinary casts. Those showing structure are reserved for a future paper.

NOTE.—With a few exceptions all the above specimens, most of them being in my cabinets, have been seen by Mr. Kidston, F.G.S., and the species confirmed by him

SECTION OF THE HALIFAX COAL STRATA
N.E. OF HALIFAX

DIP N.E. 100 FEET PER MILE



LOW[illegible] COAL MEASURES
A. Elland Flag Rock.
1. 80 Yard [illegible] Coal.
2. 48 [illegible] ”
3. 36 [illegible] ” ”
4. Hard [illegible]d ”
5. Middle Band ”
6. Soft Bed ”
7. Sand Rock ”

C. Seat Earth.

D. Marine Bed – Goniatites, Aviculopectens, &c.

E. Anthracosia Beds.

MILL STONE GRIT. B. Rough Rock.

James Spencer delt.

NOTES ON THE CAVES OF YORKSHIRE. BY S. W. CUTTRISS.

Read October 7th, 1897.

INTRODUCTION.

Yorkshire holds a unique position in England for the number, size, and variety of the caves and allied physical phenomena which are contained within its boundaries. In no other part of the country, except the neighbouring county of Derbyshire, which is to a large extent a continuation of the same geological formation, is the rock structure so favourable to their formation. Seeing these caves form such a conspicuous feature of a large part of the county, it is a matter of surprise there has been no attempt until recently to explore them in a systematic manner, and study their formation and characteristics, in the relation they bear to the topography of the country. From time to time there have been careful examinations of such caves as were of interest from an archæological point of view, principally by Dr. Buckland and Prof. W. Boyd Dawkins; also several times within the last forty years attempts, with varying success, have been made to descend some of the deep chasms or pot-holes on Ingleborough and the neighbouring mountains; but so far as the writer is aware, these investigations have been of a more or less spasmodic nature, without any apparent intention of following up the work to a complete study of the subject. Within the last few years cave exploration, as a sport, has received a large addition to its ranks, but even by the majority of these the science of Spéléologie has been neglected. To the writer this branch of geographical research has had great attractions for many years, but the number of caves is so large, and the time available for exploration so limited, that as yet only a comparatively small number have been thoroughly investigated and planned. In these notes, therefore, there will be no attempt to deal exhaustively with the subject. The chief aim rather will be to indicate a few general conclusions arrived at from work already completed. At the outset I wish to acknowledge the valuable assistance afforded by many friends in the sometimes difficult work of exploration, without whose co-operation the work in many cases could not have been accomplished.

Geological Division and Formation of Caves.

The ceaseless action of the sea on the chalk cliffs of Flamborough Head has resulted in large chambers and tunnels being formed, which, though interesting in their way, hardly come within the scope of these notes. Again, the Oolitic limestones lying to the north of the Vale of Pickering contain a few small caves and underground watercourses, but they are of no great interest if we except the Kirkdale Cave, made famous by the investigations of Dr. Buckland in the early part of the present century, and which gave occasion to the publication of his "Reliquiæ Diluvianæ." It is in that part of the county lying to the west of the great central plain, where the Carboniferous limestones and mountainous character of the country make it particularly suited to the formation of caverns and underground watercourses, that the largest number and finest examples are found. Round Ingleborough and the neighbouring mountains they are an ever-present feature of the landscape, some having the form of open chasms between 300 and 400 ft. deep, while others have ramifications underground known to extend for over half a mile from the entrance.

The base of the hills forming the Pennine Chain—the backbone of England—is composed of the Silurian slates and grits, the oldest rocks in Yorkshire. Upon their upturned edges has been deposited a mass of hard, compact limestone, the Carboniferous, Mountain, or Scar Limestone, as it is variously called. This forms an extensive plateau, through which the valleys have been cut, having a gentle dip towards the north-east of from 1 to 5 degrees, and thinning out in the same direction. Towards the west it has been cut off by the Dent Fault, its furthest extension in that direction being on the Leck Fells. Southwards it is terminated abruptly by the Great Craven Faults. From Ingleton the main line of fault runs through Clapham and Austwick to Settle, forming the Giggleswick Scars. Thence it continues in a due easterly direction by the Attermire

Scars, through Malham and across Wharfedale to Nidderdale. North of this main line of dislocation is another fault, very near the first one at Austwick, which continues eastward in a fairly straight line, about a mile and a quarter separating the two faults at Malham. The long triangular area enclosed by these faults forms a district peculiar to itself in the character of its caves. The limits of the extension of the Carboniferous Limestone towards the north and east cannot be so easily defined owing to the dip causing the rock to be obscured by the overlying strata. For the purpose of this paper we can, however, make an arbitrary boundary. From Leck Fells the line will wind round Kingsdale, up Chapel-le-Dale to the head of Ribblesdale, then down the east side of that dale, skirting Cam Fell, and Pen-y-ghent and across to Clapham. This will include nearly the whole of the Carboniferous Limestone, north of the Upper Craven Fault, which is of interest from the point of view of the present subject.

The limestone consists of a hard, compact series of calcareous beds, mostly of a light grey or bluish colour, almost without division by shales or clay. On Gragareth, Whernside, Ingleborough, and Pen-y-ghent, it attains a thickness of about 500 ft.*

Above this are a series of shales, limestones, and sandstones, collectively named by Prof. Phillips the "Yoredales" from the valley of that name, where they attain their greatest development. The combined thickness of these rocks on Ingleborough is about 700ft.† These limestones are of a different character to the Carboniferous Limestone, being, as a rule, more impure and in comparatively thin beds, with the shales and sandstones between. As a result they are not favourable to the formation of large caverns and deep fissures on Ingleborough and the surrounding hills. Towards the east, as in Wharfedale and Nidderdale, the Yoredale limestones attain a much greater thickness, and some extensive underground chambers have been formed in them. Above the Yoredales lies the

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*This is measured from the base to the present exposed surface, which is about 100 ft. lower than the actual top of the Carboniferous limestone, allowing for a total thickness of 600 ft., as given in the Memoir of the Geological Survey of the District, 1890, p. 24.

† Davis and Lees, West Yorkshire, 1878, p. 80.

Millstone Grit, which merely forms a cap on the mountains in the west. It is, however, to this cap of hard, insoluble rock that these mountains owe their preservation. Like a helmet the cap sheds the water from the top and protects the soluble rock beneath.

The whole of the limestone area under consideration can be divided into three distinct sections, which for convenience of reference may be classified as:—

1st. The Yoredales, including the rocks of that formation.

2nd. The Southern Carboniferous or Craven Section, including the Carboniferous Limestone lying between the Upper and Middle Craven Faults.

3rd. The Main Carboniferous Section, comprising the remainder of the Carboniferous Limestone outcrop, included within the imaginary boundary already defined.

The essential constituent of limestone is carbonate of lime, with which is associated in mechanical admixture a greater or less amount of earthy impurities. The carbonate is capable of being dissolved slightly in water charged with carbonic acid gas. When the water is heated and under great pressure it is able to take up a much larger proportion of lime, but these conditions do not apply in this country. Rain water, as it is precipitated from the clouds, absorbs a small amount of carbonic acid gas from the atmosphere, and gathers still more from decomposing vegetation on the ground. Finding its way into the cracks and fissures which are a characteristic feature of the rock, it carries off a portion as bicarbonate of lime, the remaining earthy impurities being washed away in mechanical suspension, or settle down in some pool as mud. The cracks into which the water first finds its way may be very minute, but particle by particle the rock is worn away, a definite line of drainage is formed, and ultimately an extensive system of underground watercourses and reservoirs created. The procees is very slow, but Nature has no need of hurry. The mechanical effect of the running water, assisted by the sand and stones carried along with it, adds its erosive action to the chemical solution of the rock and the channels more rapidly increase in size. In process of time the passages and caverns sometimes become too large to be self-supporting, the roof falls in and a rugged gorge is formed which atmospheric agencies may ultimately convert into an open valley.

As the water trickles down the subterranean cavities partial evaporation takes place, when the conditions are favourable, a portion of the carbonic acid gas is liberated, and solid carbonate of lime deposited. Inequalities in the roof or walls tend to lead the trickling water to definite points, where it drops off; the calcareous deposits at these places gradually increase in size and stalactites are formed, often of exquisite beauty and delicacy of form. Usually the deeper the cavern from the surface of the ground the purer the stalactites. Where the drops of water touch the floor, further deposits take place, which continue to grow upwards as stalagmites. Given a sufficient lapse of time, both stalactite and stalagmite unite, forming a solid pillar, sometimes of astonishing dimensions, and these may be fringed round with smaller growths. Again, the walls and floors of passages may be entirely coated with a smooth semi-transparent calcareous deposit, having the appearance of ice, and the deception in places is so perfect that one constantly anticipates a fall when walking on it. After a stream has flowed along a passage for some time, it frequently finds a lower level, the old course is deserted, and a new one formed. In these dry passages the deposition of lime is more rapid, and it is in the darkness and solitude of such lonely recesses the explorer finds most of beauty, a charm intensified by the novelty and weirdness of his surroundings.

Good examples of the more purely chemical action of water on limestone are found in the terraces and exposed surfaces of the rock on Ingleborough and the neighbouring heights, especially Moughton Fell, the combined areas of which cover many square miles of surface. The smooth surface of the rock, laid bare on the retreat of the ice during the decadence of the Glacial epoch, or having only a thin covering of drift, was exposed to the direct action of the water, which opened out the cracks in all directions, completely honeycombing the surface. The fissures thus formed are many feet deep, while the remaining ribs of rock are rounded and rotten on the top, making walking over them very tedious and even dangerous in fog or when covered with snow. The combined chemical and mechanical action of water is seen where a stream, descending from higher ground, reaches the limestone, into which it rapidly cuts a channel. The gorges thus formed are often 30 ft. or 40 ft. deep, and occasionally so narrow at the top they may be jumped across with ease. Sometimes a natural bridge of rock is left, which usually receives the appellation of God's Bridge. When the gorges have been enlarged by atmospheric denudation, they become clothed with vegetation and trees, forming picturesque retreats. Howstein in Upper Nidderdale, Ling Gill in Ribblesdale, and Yordas Gill in Kingsdale, may be cited as good examples.

I.—Caves of the Yoredales.

Turning to a consideration of the caves themselves, and following the classification already defined, the first to claim attention are those found in the rocks of the Yoredale formation. Towards the west the beds of limestones are of varying thickness, from a few feet upwards, being intercalated with beds of shale and sandstone, which, being unaffected by water, prevent the formation of high passages or caverns of large area. Being small and encumbered with accumulations of fallen rock and dirt, they do not offer much sport to the cave-hunter, nor do they materially affect the general drainage of the ground. For these reasons I have turned my attention more particularly to those in the other two divisions.

The Fox-Holes on Cam Fell, at an elevation of about 1,600 ft., may be taken as fairly typical of this class. They are in the form of narrow fissures roofed over with sandstone, very dirty, rotten, and choked with earth, through which the trickling water sinks. The rocks consist of alternate beds of dark and light limestones, highly fossiliferous (Encrinites), the dark beds being a few inches thick and the lighter coloured ones from inches to feet in thickness. Above these are soft sandstones, while underneath shale appears. The most interesting feature is the curious appearance of the limestone, the water having dissolved out the fossils on the surface, leaving a honeycombed mass of rotten rock having very much the appearance of pumice stone. The fissures will be from 25 ft. to 30 ft. in depth.

Travelling eastwards the limestones increase very much in thickness and hardness, containing many caverns of considerable dimensions and extent. Above Lofthouse in Nidderdale a triangular fault has brought the Yoredale beds to the surface. Down to this point the river Nidd, like other well-conducted rivers, runs its course above ground, then sinks out of sight and continues its underground course for over two miles, appearing to light again close to the roadside below Lofthouse. Not far from where the water sinks the underground passage can be entered at an opening called Manchester Hole, but, being obscured by thick vegetation, it is easily unobserved. Climbing down about 20 ft. the level of the water is reached, and a commodious passage entered. About 300 ft. from the entrance this opens out into a chamber 100 ft. long by 40 ft. high. At some period of its history it has been completely filled with earth, but the water has since washed part of it away at one side, leaving a steep bank of tenacious mud, which has to be crossed by cutting steps in it. At the further end of the chamber the water continues along another passage, and by dint of wading, scrambling over fallen rocks, and crawling at full length in the water, the river can be followed for several hundred feet. The roof eventually comes down close to the surface of the water, which at that point is held back by a constriction in the passage, and further progress is impossible. The rock contains fossils of the *Productus giganteus.*

About 350 yards below Manchester Hole, following the dry course of the river on the surface of the ground, is another opening in the face of a low cliff, known by the name of Goyden Pot, giving access to a large chamber and several passages, along which the river winds its way. The passage to the left, which appears the natural course to take, leads to an opening in the perpendicular wall of the cavern, 20 ft. below which the water can be heard rushing along to still lower regions. By keeping to the right of the entrance passage the cavern can be entered without difficulty, and some scrambling of a varied character indulged in. At the far end of the cavern a descent of about 18 ft. can be made to the lower level of the watercourse, and if a thorough wetting is not objected to, this may be followed for several hundred feet until the roof once more sinks to the level of the water. The furthest point it is possible to reach is about coincident with one side of the triangular fault. The vertical descent from the entrance of Goyden Pot (which is at an elevation of 705 ft. above the sea) to the "furthest possible" is 104 ft., making an average fall of 15 %. From that point to where the water issues, a distance of 1¾ miles, the average fall is considerably under 1 %; there is little probability, therefore, of ever being able to force a passage right through. An examination of the passage of débouchure below Lofthouse, to do which means wading through water 4 ft. deep, reveals it blocked entirely by a fall of the roof some 60 ft. from the opening.

Goyden Pot is an interesting cave to explore, and not difficult of access as far as the end of the large chamber, but it should not be entered in doubtful weather. Like all other mountain streams the Nidd is subject to sudden and heavy floods. As only a limited quantity of water can sink at Manchester Hole, the excess is swallowed up by Goyden Pot, making exit from the cavern dangerous or even impossible in a few minutes. At times of heavy rain the cavern fills completely, eloquent evidence of which is observed in the branches of trees firmly wedged in crevices in the roof.

In the neighbourhood of Troller's Gill, about two miles north-east of Appletreewick, in Wharfedale, is a cave of a more sporting character, from the variety of difficulties it presents to the explorer, than any other I know of in the district. Being little known to the inhabitants of the district, I give it the name of Troller's Cave as indicating the locality in which it is to be found, although on the 6-in. Ordnance Map it is designated "Hell Hole." The first complete exploration of this cave was made in 1896, by five members of the Yorkshire Ramblers' Club, Messrs. T. Booth, G. T. Lowe, Lewis Moore, J. W. Swithenbank, and the writer. At the head of the Skyreholme Dam two valleys unite—the one to the right, down which a stream of water runs between perpendicular cliffs, is Troller's Gill. Following the left-hand valley, which is dry, the entrance to a disused lead mine (Head Vein) is reached. On the top of the hill, in a direction slightly to the west of north, and about 200 yds. from the lead mine, is the entrance to the cave, at the bottom of a hollow, which is fenced on the dangerous side to prevent cattle falling down. The entrance, at an elevation of 885 ft. above the sea, gives access to a passage, about 36 ft. long, 4 ft. to 5 ft. wide, and some 20 ft. high. At the further end it branches off to the right and left. The latter passage contains a few small chambers of no great interest, except that the walls are studded with chert nodules, left protruding by the dissolving away of the surrounding limestone. It has a rapid upward inclination, receiving a small stream from the surface, which flows down into the right-hand or east passage. This branch appears to end abruptly in a few yards, but a close scrutiny reveals a low passage, the entrance to which is blocked by a large mass of rock. By chipping away the corners a hole large enough to squeeze through was made. The passage, which is entirely waterworn, rapidly decreases in size until only large enough to admit the body at full length. A waggish member of the party christened it the "Fat Man's Misery." At the far end is a perpendicular drop of 12 ft. into a small chamber. On climbing down to the bottom, it is found to communicate with another chamber of larger dimensions, but here the explorer is brought to a sudden halt on a slippery ledge, as he finds himself on the brink of a chasm down which water is heard splashing into unknown depths. Pulley-blocks were securely fastened to the walls of the chamber, and each one in turn was lowered by a rope to the bottom, 66 ft. below. Chert nodules of a much larger size than those in the upper chambers were noticed protruding from the rock a few feet below the ledge. At the bottom is a pool of water, into which the descent has to be made, the falling water forming a natural shower-bath during the descent. Several passages, having a rapid upward inclination, radiate from the bottom of the chasm, but they are encumbered with fallen stones and clay. The water sinks away in a small pool a few yards from the first one, so its further course cannot be followed, and there is no evidence of it appearing on the surface again in the valley below. The rock in the upper portion of the cave is very hard, and dark in colour, while that at the bottom is lighter, and not so hard. The temperature of the water at the bottom (115 ft. in vertical depth from the surface) was 44½° F., that of the air being 45½°. At the top of the chasm the air was 50°, and in the open 67° F.

There are many other caves in Upper Wharfedale and its tributary valleys, in some of which interesting remains have been found by earlier investigators. The most noteworthy are Elbolton Cave (Knave Knoll Hole) near Thorpe, and Dowkabottom Cave on the moorland above Kilnsey Crag. A collection of bones and relics from the latter, together with a carefully-drawn plan, are preserved in the Museum of the Leeds Philosophical Society.*

II.—Caves of the Southern Carboniferous or Craven Section.

Although the Yoredale rocks are geologically included in the Carboniferous epoch, as well as the underlying limestone, to which the distinctive name of Carboniferous Limestone has been given, yet it is convenient for the purpose of these notes to separate the two, and use the title Carboniferous only as distinguishing a particular kind of rock, and not a geological division.

The district included in this section is that lying between the North and Mid-Craven Faults. It is in the form of a long triangular strip, 10 miles from east to west, and 2½ miles from north to south at Settle, its broadest part, where the valley of the Ribble practically cuts it into two portions. Although, lithologically, this area is part of the Carboniferous limestone outcrop, yet an investigation of its caves shows them to have distinctive features generally absent in those north of the line of dislocation. Briefly, these differences consist in the absence of running water, and the filling up of the entrance with clay, &c., together with rock *débris* from the overhanging scars. The scars principally face the south and west, and the dip of the strata is about 10° towards the north-east, which is also the direction of the rock drainage above the Attermire and Langcliffe Scars. During the Glacial epoch, the district was over-ridden by ice, which flowed down the Ribble Valley, and this was probably the principal agent at work in closing the mouths of the numerous caves in the faces of the scars.

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*(See the Proceedings of the West Riding Geological and Polytechnic Society, 1859 and 1864-5-6. H. Speight, The Craven and N.W. Yorkshire Highlands, 1892, page 295.)

The well-known Victoria Cave, on the face of the Langcliffe Scars, is about 1½ miles from Settle. It was discovered accidentally by Mr. Joseph Jackson, of Settle, in the year of Her Majesty's Coronation, whence the name of the cave. Mr. Jackson discovered many relics, including coins, pottery, bone and bronze implements (Speight's "Craven Highlands," p. 119). The cave was opened out in 1870, under the auspices of the British Association, and bones of the reindeer, bear, bison, fox, Arctic hare, &c., were found in the upper layers of deposit, while those of the mammoth, hippopotamus, and cave-hyæna were discovered in the lowest bed.*

There are several other caves in the neighbourhood which would, no doubt, yield similar results if the necessary funds were forthcoming to enable excavations to be carried out. The only other cave which can at present be explored to any extent is Attermire Cave, on the scars of that name, about half-a-mile south of Victoria Cave. Having spent some time carefully examining the cave, and, with the assistance of Mr. T. Gray, completed a plan of the interior, I will give a somewhat detailed description. Its existence has been known for ages, and it was partly cleared for occupation at the time of the Rebellion of 1745, as well as during the war panics at the end of last century (Speight's "Craven Highlands," p. 127). The entrance is high up on the face of the scar, at an elevation of about 1,350 ft. above the sea. On entering, the attention is at once attracted by the manner in which the rock has been hollowed out on one side, and would suggest a considerable flow of water at some period. Whether it was caused by the natural drainage of the cave flowing outwards, or the result of erosion by water flowing inwards during the Glacial period, is a question on which I will not venture to express an opinion. There is now no flow of water through any part of the cave, and but for drippings from the roof and walls forming a few pools, it is practically dry. Although the entrance bears strong evidence of running water, it is probable the cave does not owe its existence to that action alone, but was primarily a fissure, resulting from the development of the neighbouring fault. The floor is everywhere very irregular, being strewn with fragments of rock, which in many places are cemented together and coated with calcareous deposit. It is narrow throughout, varying from 1 ft. to 4 ft. wide in the passages. The Pool Chamber, 160 ft. from the entrance, practically divides the cave into two portions, the inner one being generally lofty, varying from 30 ft. to 40 ft. high (except a small lateral passage at the extreme end), while the outer portion is comparatively low, and at one place most emphatically so. This place, designated the Neck, is only about 15 in. high by 12 in. wide, but even this is larger than the original dimensions, as several drill marks in the rock show it to have been artificially enlarged at some time. On the walls, at a level a little above the top of the Neck, are stalactite tide-marks, which can be traced to within a few feet of the entrance. When this became blocked with clay the water accumulated in a pool, and the tide-marks were formed at its surface by the calcareous deposit. When the cave was cleared out, two large conglomerate blocks were left bridging the passage, about 10 ft. above the floor. Specimens broken off consist of pebbles of quartz and sandstone, with fragments of chert, the whole being cemented firmly together.

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*A full description of the cave and its contents is recorded in Prof. W. Boyd Dawkins' "Cave Hunting," 1874, Macmillan.

The Neck is not the most agreeable place imaginable to squeeze through, especially if there is 4 in. or 5 in. of water on the bottom. By wriggling along at full length, with a candle in one hand, and a bag containing the surveying instruments, gripped by the teeth, to keep it clear of the water, we managed to pass the obstacle. On the other side another tide-mark has been formed for a distance of a few yards until it merges in the rising floor. A small chamber (Pool Chamber) is now reached, about 40 ft. high, the walls of which are coated to a considerable thickness with calcium carbonate. On the floor is a shallow pool of clear water, which at one time probably formed the basin of a small waterfall. At a first glance this appears to be the termination of the cave, but further examination reveals a lateral passage, which descends rapidly in a series of steps. The walls, together with the rocks forming the steps, are completely covered with a thick ice-like coating of travertine, giving the steps the appearance of a frozen cascade when viewed from the bottom. The passage continues for about another 150 ft., being much encumbered with fallen rocks, all cemented fast; then again it apparently terminates abruptly, but by climbing down a small hole on the west side, another small passage can be followed for about 40 ft., when it gets too contracted to permit of further progress. The total length of the cave from the entrance is 460 ft. At one time it has been well decorated with stalactites, but now not a single one within reach has escaped the hands of the vandal. The air temperature at the furthest point reached was 48° F., and at the entrance 58° F. At the bottom of the staircase a current of air, sufficient to deflect the flame of a candle quite 45°, was observed flowing outwards towards the entrance. At the Neck, our attention was so fully occupied with other matters, we omitted to observe if the air current was apparent there also. At the south end of the Attermire Scar is a high fissure-like cave, partially filled with clay, the longitudinal axis of which is a continuation of that of the main passage in Attermire Cave, with which, I was on one occasion able to ascertain, it directly communicates, although the connection between the two is now blocked with clay. At one time, therefore, the cave had two outlets, the latter, probably, being the main one.

Assuming the majority of the caves in this section were either formed by water, or acted as drainage channels, they must be of greater age than those to the north of the Upper Craven Fault, as, although the latter are generally more extensive in their ramifications and of greater sectional area, they mostly have running water in one or other of their passages. This absence of running water is also to be accounted for by the present configuration of the ground. During their formation the Carboniferous Limestone would in all probability be overlaid by the Yoredale strata, which might have shed their drainage towards the south, the caves forming the drainage channels. At the present day none of this higher ground remains, the limestone being entirely exposed. The rock drainage above Attermire is now actually reversed, following the dip of the strata.

It is hardly probable that the tilting of the strata, resulting from the elevation caused by the great Craven dislocation, would have been solely, if at all, responsible for this change in the aspect of the caves.

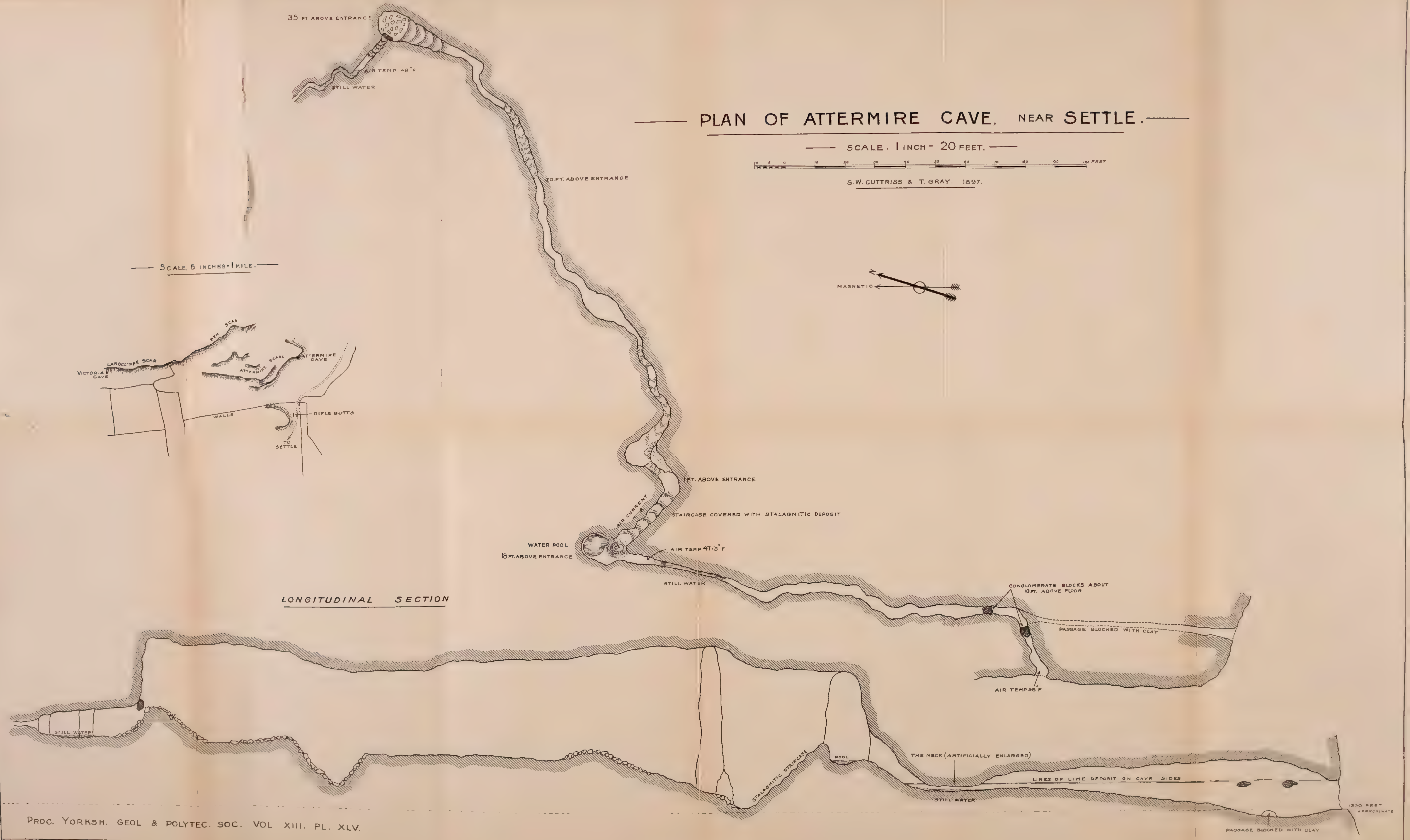
A distinctive feature of this section is the entire absence of pot-holes. For a long time this difference between two adjacent districts in the same formation was very perplexing, as pot-holes are characteristic of the other section. The solution of the problem was, however, eventually found to be quite simple. A pot-hole differs from a cave, in the ordinary acceptation of the word, in that it is a more or less vertical pit, down which a stream of water plunges, often to an enormous depth. (The deepest at present known in this country is Rowten Pot, in Kingsdale, which has a depth of 365 ft.) Bearing in mind the fact that here the limestone is entirely uncovered, except for the surface soil, and does not receive drainage from higher ground, the one agent necessary to the formation of pot-holes is absent, viz., a more or less perennial stream. The rain falling on the ground at once sinks below, without collecting in surface streams. For this reason pot-holes need never be looked for where limestone forms the highest ground.

Sink-holes or swallow-holes are observed in all limestone districts, being merely conical depressions in the ground caused by the dissolving away of the rock, at those places specially favourable for absorbing the surface water. Many of these sinks, some of considerable size, are on the open ground above the Attermire Scars, indicating distinct lines of subterranean drainage towards the north-east.

PLAN OF ATTERMIRE CAVE, NEAR SETTLE.

SCALE. 1 INCH = 20 FEET.

S.W. CUTTRISS & T. GRAY. 1897.



PROC. YORKSH. GEOL & POLYTEC. SOC. VOL XIII. PL. XLV.

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ON THE FOSSIL FISHES OF THE UPPER LIAS OF WHITBY. PART III.

BY ARTHUR SMITH WOODWARD, F.L.S., F.G.S., OF THE BRITISH MUSEUM (NATURAL HISTORY).

Plates XLVI.-XLVIII.

Family Semionotidæ.

Lepidotus semiserratus, Agassiz.

Plates XLVI.-XLVIII.

1822. *Esox*, Young and Bird, Geol. Surv. Yorkshire Coast, p. 261, pl. xvi., figs. 7, 8.
1833. *Lepidotus latissimus*, L. Agassiz, Poiss. Foss., vol. ii., pt. i., p. 8 (undefined).
1833. *Lepidotus umbonatus*, L. Agassiz, *ibid.*, p. 8 (undefined).
1837. *Lepidotus semiserratus*, L. Agassiz, *ibid.*, p. 240, pls. xxix. *a*, *b*.
1837. *Lepidotus rugosus*, L. Agassiz, *ibid.*, p. 247, pl. xxxiii. *a*, fig. 1 (*errore*).
1849. *Lepidotus semiserratus*, W. C. Williamson, Phil. Trans., p. 441, pl. xl., figs. 3, 4.
1895. ,, ,, A. S. Woodward, Catal. Foss. Fishes, B.M., pt. iii., p. 85.

Type: Imperfect fishes; Whitby and Scarborough Museums.

The commonest ichthyolites of the Whitby Lias are remains of a species of *Lepidotus* now generally known under the name of *Lepidotus semiserratus.* The earliest notice of them appears to occur in Young and Bird's "Geological Survey of the Yorkshire Coast," where two specimens in the Whitby Museum are briefly described and unsatisfactorily figured. According to these authors, the fish represented by the fossils "seems to belong to the genus

Esox (the pike), several species of which have bony scales; and it seems most akin to the *Esox Leverianus*, or the *Esox Chilensis*." In 1832 a slab apparently of the Whitby Lias with scales of the same fish, was recognised by Agassiz in the Paris Museum, and this he provisionally named *L. latissimus*; about the same time he found the caudal region of another fish, which he believed to be distinct, in the collection of M. Régley, of Paris, and this received the provisional name of *L. umbonatus*. In 1834 Agassiz visited Whitby and identified the fossils he had examined in Paris with those originally described as pikes by Young and Bird, while three years later he published his detailed description of the species under the name of *L. semiserratus*. Specimens were also identified in the museums of Scarborough, York, Newcastle, and Oxford, and in the private collections of Earl Fitzwilliam and Mr. Randyl, of Stockton. At the same time he hypothetically—and, as it now appears, erroneously—referred a very imperfect skull of the same fish in the Whitby Museum to another ill-defined form, the so-called *Lepidotus rugosus*; but the latter name proves to have been applied chiefly to specifically indeterminable fragments of the squamation and opercular apparatus of members of the family Eugnathidæ, one from Whitby (Proc. Yorks. Geol. and Polyt. Soc., vol. xiii., p. 35), the others from Lyme Regis.

In 1849 Prof. W. C. Williamson described the microscopical structure of the scales; but otherwise no further contribution to our knowledge of the Whitby *Lepidotus* has been made within the last half century. A new detailed and illustrated description of the fish, in the light of the most recent research, has thus become requisite for comparison with the discoveries made in the Upper Lias of the European Continent since the studies of Agassiz were undertaken. The fine series of specimens now in the British Museum exhibit nearly all the principal characters of the species, and these suffice for the technical account of the skeleton of the fish which follows.

The smallest detached skull (Brit. Mus., No. 35,556) is remarkable for the comparative smoothness of its external bones. It displays especially well the whole of the cranial roof except the

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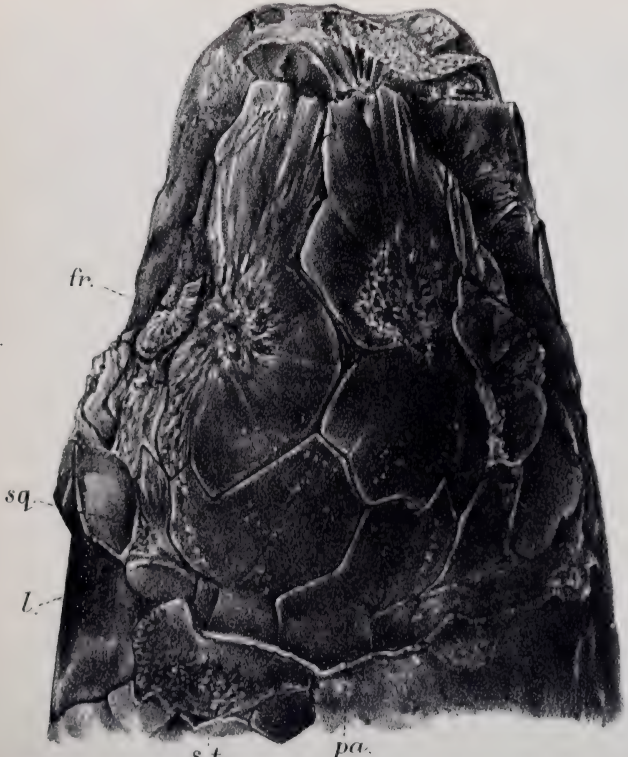

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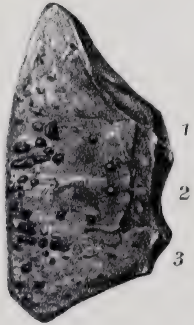

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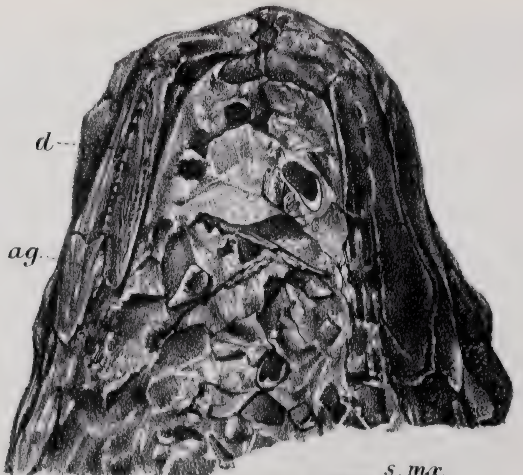

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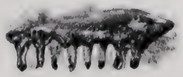

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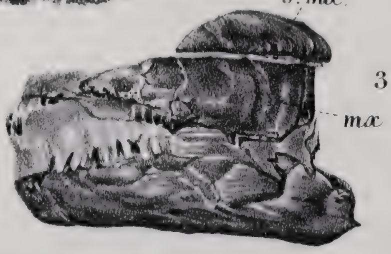


J. Green del et lith.

Mintern Bros. imp.

LEPIDOTUS SEMISERRATUS.

ethmoidal region (pl. xlvi., fig. 1). The roof is flattened in the middle, but curves sharply downwards on either side; and it slopes gradually with very little convexity from the occiput to the snout. The occipital border is overlapped by a single pair of supratemporal plates (*s. t.*), which are somewhat fractured and displaced forwards in the fossil. They are transversely elongated and irregularly triangular in shape, and their acute apices meet in the middle line. Their external surface is smooth anteriorly, but marked by irregular tubercles and ridges, more or less radiating from the course of the transverse slime-canal in the hinder half. The parietal bones (*pa.*) form a very unsymmetrical pair, and their maximum extent equals at least one-third of the total length of the cranium. That of the left side is much the largest, the suture between the two elements being sharply diverted towards the right in front of an acute bend which occurs at the level of the transverse slime-canal. This canal is marked upon the bone on either side by a short groove, which is directly continuous with a similar groove on the squamosal bone (*l.*), and soon abruptly turns backwards at right angles to the occipital border. The external surface of the parietals is, for the most part, smooth, with mere traces of tubercles, and a few scattered small pits, probably for slime glands. The squamosals (*sq.*) are long and narrow, truncated behind and pointed in front; they do not extend so far backwards as the parietals, but reach a point quite as far forwards, and are thus partly in contact with the frontal on either side. Their external surface exhibits more tendency to rugosity than that of the parietals. The length of each frontal (*fr.*) equals about two-and-a-half times its maximum width; and this pair of bones meets in a very wavy median suture, which exhibits two sharp bends, and one slighter bend further forwards. The frontals taper considerably in front, while their middle and postero-lateral portions are marked with some rugosity. Their outer margin above each orbit is slightly excavated for the accommodation of the upper plates of the circumorbital ring, which are partly shown, though much crushed and disturbed on both sides. These plates, so far as preserved, are more strongly ornamented with tubercles and short rugæ than the cranial roof; and three of the lower circumorbitals, which are well exposed on the left side, exhibit the ornament only in the peripheral half, where it is somewhat radiating. The remains of the posterior suborbitals are quite smooth. The uppermost plate of this series, best shown on the left side, is in contact with the concave outer margin of the squamosal, but has not more than half the antero-posterior extent of the latter element; it is quadrilateral, but deepest in front and gradually tapering towards the hinder border. The plate immediately below this is clearly deeper than broad, with slightly concave anterior and inferior margins. The remains of the upper jaw are too imperfect for description, but there are traces of stout, styliform upper teeth towards the end of the snout. The mandibular rami are sharply curved inwards at the symphysis, almost forming a horse-shoe bend (pl. xlvi, fig. 1*a*); and on both sides of the jaw the suture is distinct between the long dentary bone (*d.*) and the comparatively short and deep angular element (*ag.*). The preoperculum is shown on each side to be a narrow arched bone, apparently tapering to a point above at some distance beneath the cranial roof (see page 329), and not much expanded in its lower half, where it is marked by the usual longitudinal sensory canal, from which rugose markings radiate backwards. The other opercular plates are quite destitute of ornament. The operculum is narrowed upwards, and its maximum width on both sides is shown to be about two-thirds its depth. The maximum depth of the suboperculum is half its greatest width; and a small process is directed upwards from its antero-superior angle. The interoperculum is a comparatively small triangular plate, antero-posteriorly elongated. No branchiostegal rays are preserved, but remains of the partly-displaced squamation extend forwards, even between the hinder ends of the mandible. The scales of this region are relatively small and very deeply overlapping.

Another skull, with remains of the anterior part of the abdominal region (Brit. Mus., No. P.3528*a*), is much fractured, but exhibits more of the cheek-plates and dentition than the last specimen. It is shown of two-thirds the natural size from the right lateral aspect in pl. xlvii., fig. 1. The remains of the frontal parietal, and squamosal bones of the cranial roof exhibit a sparse and rather coarse tubercular ornament; but the relative proportions of these elements seem to be approximately similar to those of the specimen already described. The margin of the orbit (*orb.*) is clear on the right side, being defined as usual by a complete ring of circumorbital plates (*c. o.*). The uppermost circumorbitals, which are in contact with the frontal margin, seem to be the largest, and two are especially well preserved on the left side, where the tuberculated external surface is shown. The foremost of these upper plates is trapezoidal in shape, not only forming the antero-superior part of the circumorbital ring, but also extending forwards above the hinder of the three antorbital plates (*a. o.*). Each of the latter is deeper than broad, with a comparatively smooth external surface; and the three plates together completely fill the space on the cheek between the cranial roof, the upper jaw, and the circumorbital ring. Of the comparatively large hinder cheek-plates or suborbitals, only the two lower elements remain on the right side (*s. o.*) These are irregularly trapezoidal in shape, as indicated in the figure, and their external surface seems to be rugose rather than tuberculated. The removal of the upper suborbitals has exposed the greater part of the hyomandibular (*hm.*); but both this and the jaw are too imperfectly displayed for precise description. Remains of a delicate lamina of bone, with traces of a close series of relatively small and slender styliform teeth on its oral border, may doubtless be interpreted as representing the maxilla (*mx.*), and this bone is clearly deeper behind than in front. The premaxillæ are lost, and the maxilla is also destroyed on the left side, where is exposed a thick, tooth-bearing bone, evidently to be regarded as the vomer (fig. 1*a*). All the teeth borne by this element are broken except two, and these are both stouter and larger than those of the maxilla; they have a tumid crown on a styliform base. The mandible is very much broken and exhibits no special features of interest. Adjoining the posterior border of the two lower suborbital plates, the inferior slightly expanded and rugose end of the preoperculum (*p. op.*) is well shown, and fractured remains of this element are traceable upwards as far as the hinder angle of the squamosal. Although, therefore, the preoperculum does not appear to reach the cranial roof when the cheek-plates are all in position, it really completes that extension beneath the upper suborbitals. The operculum (*op.*) and suboperculum (*s. op.*) are similar to those of the last specimen, and there are also fractured remains of an interoperculum (*i. op.*) of corresponding proportions. The external surface of these bones is not well preserved, but it may be noted that there are no traces of a tubercular ornament. The only doubtful indications of branchiostegal rays are some fragments at the hinder end of the right mandibular ramus. The head is crushed upon the remains of the trunk in such a manner that the clavicular arch and post-clavicular plates are obscured; but some of the anterior series of scales are very well exhibited. The median dorsal ridge-scales are shown to be at least as small as the adjoining upper flank-scales, and they are not produced into a conspicuous point or spine behind. The exposed enamelled portion of the principal flank-scales is deeper than broad, and the hinder border is serrated in its lower half or lower two-thirds, the acute denticles being directed obliquely downwards and apparently continued as short feeble ridges on the bone beneath the superficial enamel. The smaller upper and lower flank-scales are not serrated, but their postero-inferior angle is produced into a slender point. The right pectoral fin is enveloped in a mass of hard matrix, on the surface of which the characteristic double row of fringing fulcra (*pct.*) is very well displayed.

Another more imperfect head in the British Museum (No. P.5213) of the same size as the last, also shows the coarse tuberculation of the cranial roof and the cheek-plates; but the operculum and suboperculum still remain smooth. The most interesting feature of this specimen, however, is the preservation of the large, deepened posterior suborbital (pl. xlvi., fig. 2), which exhibits three distinct surfaces of overlap (1, 2, 3) for circumorbitals in front.

Still another larger specimen (Brit. Mus., No. P.7410) has the coarsely-tuberculated and rugose cranial roof and cheek-plates, so that the comparative smoothness of these bones in the first skull described is evidently a mark of immaturity. The operculum and suboperculum, however, still remain almost destitute of ornament, only very few tubercles being observable on these plates. Remains of the suborbital cheek-plates on the left side seem to indicate that the series consists of five elements. Uppermost, there is the small trapezoidal plate already noticed in No. 35,556; next follows the deep plate just described in No. P.5213 (pl. xlvi., fig 2); immediately below this are two plates, the upper one as deep as broad, the lower twice as broad as deep, which seem to correspond with the single plate shown just below the fracture in No. P.3528*a* (pl. xlvii., fig. 1); and the series is completed by the large trapezoidal element, which is also well displayed in the latter specimen.

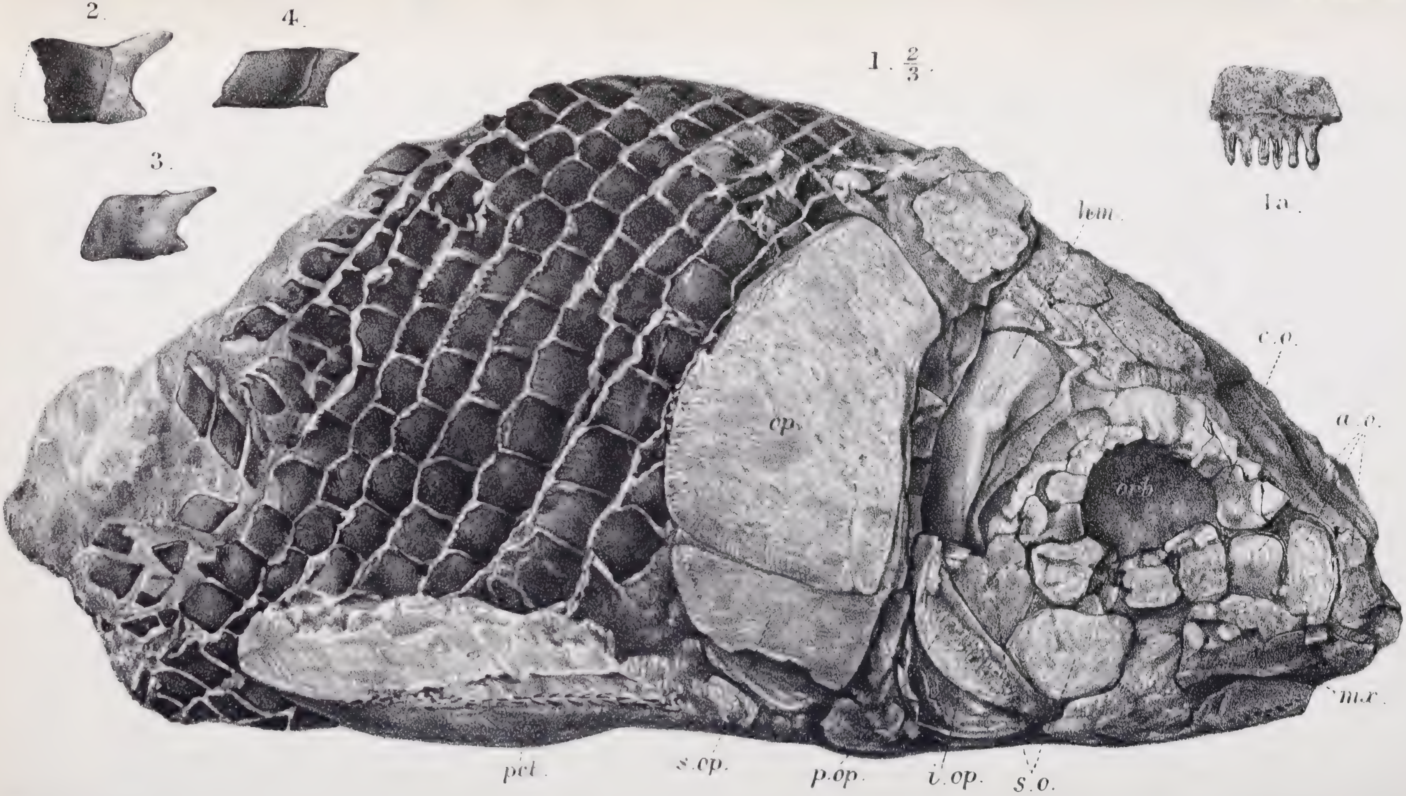
The head of another small fish in the British Museum (No. P.7409) has comparatively smooth cranial and facial bones like the first specimen already described. It is of special interest as displaying the maxilla and posterior suborbital plates. The maxilla evidently tapers in front, and gradually deepens behind, until it terminates suddenly in a truncated posterior end (pl. xlvi., fig. 3, *mx.*). The outer face of this element is quite smooth, and the anterior half of its lower border exhibits remains of slender styliform teeth. Above the hinder half of the bone there is a relatively large supramaxilla (*s.mx.*), which is also smooth and delicate, and tapers to a point at each end. In the suborbital series the two upper plates seem to be fused together into a very deep bone; and there are only two plates beneath it, as in No. P.3528*a*. Below the interoperculum there are distinct indications of three or four branchiostegal rays. The scales of the trunk are much displaced, and some of those towards the ventral border display not only the normal small peg-and-socket articulation, but also an extremely produced antero-superior angle.

The teeth of the dentary bone are very imperfectly shown in the specimens just described, but the mandible of one imperfect fish in the British Museum (No. P.6394) appears to exhibit the complete series. The teeth are styliform, with a short enamelled crown, like those of the maxilla, though somewhat larger; they are uniform in size, and regularly spaced, and seem to have been thirteen in number on each side. The dental series of the premaxilla, as shown by

Brit. Mus., No. P.5223, is exactly similar in character to that of the dentary, but comprises only eight teeth (pl. xlvi, fig. 4).

Two of the best-known specimens displaying the general proportions of the fish are shown of one half the natural size in pl. xlviii. The first of these (Brit. Mus., No. P.3528) is exposed from the left ventro-lateral aspect, exhibiting the head and parts of all the fins, except the dorsal. The second (Brit. Mus., No. P.3527) is exposed in direct side view, displaying the greater part of the squamation in undisturbed order.

The head of the first of these two fishes (fig. 1), though very imperfect, is interesting as confirming some of the observations made above in reference to the other skulls. Being a small fish, the cranial and cheek-plates are very slightly tuberculated, while the opercular apparatus is quite smooth, as usual. The deepened posterior suborbital is preserved on both sides, and the normally single plate adjoining its lower border on the left side is here divided into two by a transverse suture, as in No. P.7410. The lowermost suborbital appears as usual. The characteristic maxilla is seen on both sides, but the premaxillæ are broken away. The rami of the mandible (*md.*), viewed from beneath, exhibit the characteristic inward curve at the symphysis, and between them one of the ceratohyal bones seems to be exposed, very narrow in front, considerably expanded behind. Below the opercular apparatus on the left side, there are also remains of about four branchiostegal rays, the uppermost relatively large and broad. Parts of both pectoral fins (*pct.*) are shown, comprising stout and slightly-arched rays, which are undivided for more than half of their length, but are cleft distally into very fine jointed filaments. About thirteen of these rays are indicated in the left pectoral, but the series preserved is probably not complete. Both pelvic fins (*plv.*) are also imperfectly shown, and these seem to be about two-thirds as large as the pectorals. Their rays are similar, but only about six or seven in number; and there are traces of the series of slender fulcra on the anterior border of the fin of the right side. The distance between the origin of the paired fins is somewhat less than twice as great as that between the pelvic pair and the anal fin; while the latter (*a.*) seems



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LEPIDOTUS SEMISERRATUS.

to arise just in front of the middle point between the pelvic fins and the caudal. The rays of the anal fin are rather stouter than those of the paired fins, and the undivided base of each is relatively much shorter, being less than half the total length of the ray. The broken remains of large, slender fulcra are observed on the anterior border of this fin ; and its rays, to the number of seven or perhaps eight, are separated by interspaces somewhat greater than their own width. The caudal fin rays (*c.*) are observed to be remarkably stout, finely subdivided, and very closely articulated almost to the base. The squamation is considerably broken and displaced, while many of the scales have lost their external layer of ganoine, and display the characteristic concentric structure of their bony basal portion. The scales of the ventral aspect are smaller than those of the flank ; they are almost equilateral in shape, and when their hinder border is preserved it always appears to be destitute of serrations. Only two modified scales are seen, and these evidently bounded the anus in front of the origin of the anal fin. Both are much enlarged but quite smooth. The foremost (*m. a.*) is evidently bilaterally symmetrical, and transversely arched to occupy the median line of the body; while it ends behind in a broad point which is subdivided into short digitations. The hinder of the two scales (*l. a.*) is thrust to the left side ; and this is known from other specimens to be one of a symmetrical pair. All the scales preserved on the caudal region are quite smooth and longer than deep ; and a few near the base of the caudal fin are of a distinctly irregular shape.

The second well-preserved fish (pl. xlviii., fig. 2) is interesting as showing the general proportions of the head and trunk. It is imperfect both at the extremity of the snout and at the hinder border of the caudal fin, while the ventral scales in the abdominal region are clearly a little crushed downwards ; but making due allowance for these deficiencies, it may be justifiably inferred from the specimen that the length of the head and opercular apparatus was originally about equal to the maximum depth of the trunk, which would be contained approximately four times in the total length of the fish. There is nothing worthy of note in the remains of the head ; but the greater part of the clavicle (*cl.*) is exhibited behind and below the opercular apparatus. Its flattened external face is rather broad, apparently quite smooth and destitute of enamel. It is bordered posteriorly by the usual enamelled post-clavicular plates (*p. cl.*), of which the two uppermost are well displayed above the hardened clay containing fragments of the pectoral fin. Their hinder margin does not bear any serrations. The principal scales of the flank in the abdominal region are deeper than broad; while those both dorsally and ventrally are observed to be smaller and more nearly equilateral, or even broader than deep. Many of the former exhibit conspicuous serrations on the lower half of their hinder margin, but the latter are entirely smooth. On the tail the scales gradually become much smaller, and nearly all of them are broader than deep, with the postero-inferior angle—sometimes also the antero-superior angle—produced into a slender point. All are quite smooth, without serrations; while some towards the ventral border and at the base of the caudal fin (*c.*) are very irregular in shape. At the base of the anal fin (*a.*) there are also remains of the enlarged anal scales. The course of the lateral line on the flank is indicated by a series of simple perforations, sometimes with a partly raised rim, extending along a row of scales from a point just above the upper postclavicle to the middle of the caudal pedicle. No scale of this row is pierced by more than one opening, and for the most part only the alternate scales appear to be marked.

The two fine examples just described show very little of the overlapped anterior margin and the inner face of the scales. These features are better observed in the scattered squamation of Brit. Mus., No. P.5223, from which the originals of pl. xlvii., figs. 2-4, are taken. Fig. 2 represents an abdominal flank-scale, imperfect behind but beautifully exhibiting the anterior overlapped margin, which is extended at its antero-superior angle into a long prominence, and is also slightly produced forwards antero-inferiorly. Fig. 3 shows the inner aspect of a scale, probably from the postero-dorsal part of the abdominal region. The anterior overlapped border exhibits the characteristic prominences noticed in the previous specimen; a broad rounded ridge or thickening extends vertically across the middle of the inner face of the scale; and above this at the upper margin there is a minute articular peg. The third scale, shown from the outer aspect in fig. 4, evidently belongs to the caudal region, and the angles of its overlapped border are much less produced than those of examples from the abdominal region.

Taking into consideration all the specimens of the Whitby fish thus described, it is possible to form a tolerably complete idea of its principal external characters. We are, therefore, able, more satisfactorily than hitherto, to diagnose the species and determine its relationships to the other known forms of *Lepidotus.*

The first interesting point is the discovery of the vomerine dentition, which comprises stouter teeth more adapted for grinding than those on the margin of the jaws. The second most striking feature is the new demonstration that the overlapped border of the abdominal flank-scales is as much produced at its anterior angles as in the later fishes which are referred to *Lepidotus.* The recognition of the supramaxillary bone adds a new feature of resemblance between *Lepidotus* and *Dapedius*; while the renewed demonstration of the absence of a gular plate proves the generic distinctness of even the most generalised species of these two types. For *Lepidotus semiserratus* is indeed one of the most generalised species of its genus; exhibiting no ossified vertebral rings, no irregular subdivision of the cheek-plates and supratemporals, and no excessive development of grinding teeth, such as characterise many of the later forms.

Comparing the Whitby species with the other known forms, it is clearly most closely related to the type species of the genus, *Lepidotus elvensis*, from the Upper Lias of Würtemberg, Bavaria, Northern France, Northamptonshire, and Somersetshire.* It is also very similar to the somewhat smaller earliest known species of true *Lepidotus*, the so-called *Prolepidotus gallineki*, from the Rhætic formation of Neudorf, near Landsberg, Upper Silesia.† From these and all other sufficiently well-known forms of the genus, however, the Whitby fish may be readily separated by the following *specific diagnosis*:—

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* See references in Catal. Foss. Fishes, B. M., pt. iii., p. 84.

† R. Michael, Ueber eine neue Lepidosteiden-gattung aus dem oberen Keuper Oberschlesiens, Zeitschr. deutsch. geol. Gesell., 1893, pp. 710-729, pls. xxxiii., xxxiv.

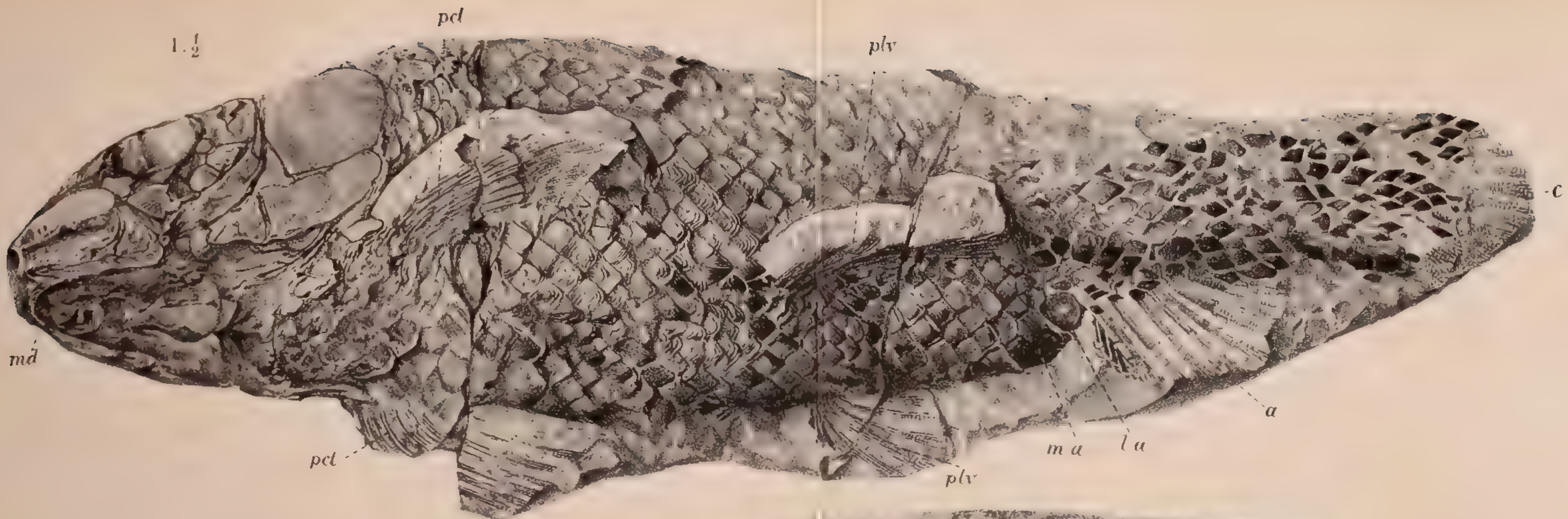
A robust, round-bodied species, attaining a length of somewhat more than half a metre. Length of head, with opercular apparatus, about equalling the maximum depth of the trunk, and contained four times in the total length of the fish. The cranial roof-bones and cheek-plates more or less sparsely tuberculated and rugose, but the maxilla and opercular apparatus smooth. Supratemporal plates forming a single symmetrical pair; parietals relatively large, extending at least over one-third of the total length of the cranial roof, both these and the frontals meeting each other in a wavy, sharply-angulated suture; the length of each frontal about two-and-a-half times its maximum width; suborbital cheek-plates four or five in number, the one directly behind the eye relatively large and deepened; antorbitals three in number, deeper than broad. Marginal teeth slender styliform, about eight in the premaxilla, and thirteen in the dentary, these of nearly equal size, those of the maxilla slightly smaller. Operculum two-thirds as broad as deep, suboperculum twice as broad as deep, and the narrow preoperculum covered by the suborbitals at its upper end. Fin-fulcra moderately developed, slender; pelvic fins arising nearer to the anal than to the pectorals; anal fin midway between the pelvic pair and the caudal fin. Scales smooth; the principal flank-scales slightly deeper than broad, with a few coarse serrations on the lower half of the hinder margin; dorsal ridge-scales relatively small and inconspicuous; enlarged median anal scale with digitate pectinations at its tapering hinder end.

EXPLANATION OF PLATES.

Plate XLVI.

Fig.		Page.
1.	*Lepidotus semiserratus*, Agassiz; roof of skull. *fr.*, frontal; *l.*, groove for slime-canal; *pa.*, parietal; *s.t.*, supratemporal; *sq.*, squamosal. [35556.] … … …	326

1. $\frac{1}{2}$



2. $\frac{1}{2}$

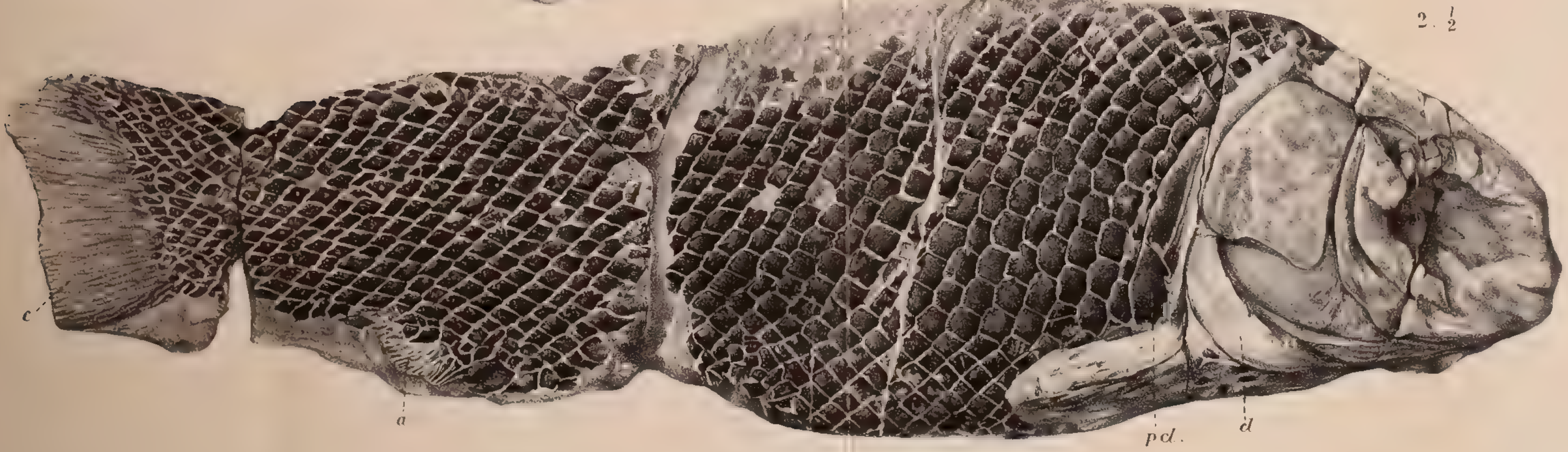


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Fig.		Page.
1*a*.	*Lepidotus semiserratus*, Agassiz; mandible of same specimen from below. *ag.*, angular; *d.*, dentary. ...	328
2.	Ditto; large posterior suborbital plate, left side. 1, 2, 3, facettes for three circumorbitals. [P.5213.] ...	330
3.	Ditto; left maxilla (*mx.*) and supramaxilla (*s.mx.*), outer aspect. [P.7409.]	331
4.	Ditto; dentition of left premaxilla, outer aspect. [P.5223.]	332

Plate XLVII.

1.	*Lepidotus semiserratus*, Agassiz; head and anterior abdominal region, right lateral aspect, two-thirds natural size. *a.o.*, antorbital; *c.o.*, circumorbital; *hm.*, hyomandibular; *i.op.*, interoperculum; *mx.*, maxilla; *op.*, operculum; *orb.*, orbit; *p.op.*, preoperculum; *pct.*, pectoral fin; *s.o.*, suborbital; *s.op.*, suboperculum. [P.3528*a.*]	328
1*a*.	Ditto; portion of vomer of same specimen.	329
2-4.	Ditto; three scales from one and the same fish, the first and third from the outer aspect, the second from the inner aspect. [P.5223.]	334

Plate XLVIII.

1.	*Lepidotus semiserratus*, Agassiz; imperfect fish, left ventrolateral aspect, one-half natural size. *a.*, anal fin; *c.*, caudal fin; *l.a.*, lateral anal scale; *m.a.*, median anal scale; *md.*, mandible; *pct.*, pectoral fins; *plv.*, pelvic fins. [P.3528.]	332
2.	Ditto; imperfect fish, right lateral aspect, one-half natural size. *a.*, anal fin; *c.*, caudal fin; *cl.*, clavicle; *p.cl.*, postclavicular scales. [P.3527.]	333

Note.—All the specimens represented on these plates are preserved in the British Museum, and the numbers in square brackets refer to the Register of the Department of Geology. Unless otherwise stated, the figures are of the natural size.

FILEY BAY AND BRIGG.

BY C. FOX-STRANGWAYS, F.G.S., OF H.M. GEOLOGICAL SURVEY.

Plates XLIX.-LVI.

The series of eight views, which are now published in continuation of those given last year of the neighbourhood of Flamborough Head and Speeton, serve to show the structure of the cliffs at the opposite horn of this extensive bay. The whole of the views are taken within a little more than a mile of the town of Filey, and illustrate very clearly many of the details of the northern promontory of the bay known as the Carr Naze, and the remarkable reef of rocks forming Filey Brigg.

To those who have studied the geology of this fine and interesting coast, the illustrations require but little explanation; a short descriptive notice of the rocks may, however, be acceptable to others who are not so well acquainted with its intimate structure. Filey Brigg and the neighbouring cliffs afford magnificent sections of the middle portion of the Jurassic rocks, and of the Boulder Clay and other glacial beds by which these are so deeply covered along their eastern edge. The Jurassic rocks here shown comprise the sandy and calcareous strata of the Middle Oolite which inland form that remarkable range of tabular hills stretching from Scarborough to Black Hambleton above Thirsk, where they attain an elevation of 1,300 ft. above the level shown in these views.

Filey Brigg is the eastern extremity of this extensive outcrop, and is especially interesting to the geologist from the rocks being easily accessible, and from the fact that great alteration takes place in their character, just before they are lost beneath the waters of the North Sea.

1. Filey; Town and Bay looking Southward.

This is a general view of Filey as seen from the cliffs at the northern end of the town. The whole of these cliffs, which are here a little over 100 ft. in height, and upon the slopes of which the town is built, are composed of Boulder Clay and other glacial beds. The Jurassic rocks upon which these rest are not seen in this part of the bay, and probably lie at some little distance below the level of the water. Patches of Lias clay, however, have been found on the shore a short distance south of the town, which were at one time supposed to be *in situ*; but there is no doubt that they are large drifted masses which have been forced here by the action of the ice.

This view helps to give some idea of the graceful curve formed by the bay as it sweeps round towards Speeton Gap and the Chalk cliffs of Flamborough, distant between four and five miles, which were so well illustrated by the series of photographs taken by Mr. Godfrey Bingley, and described by Mr. Lamplugh in his interesting account published in last year's Proceedings.

The low cliffs seen in the picture are constantly being undermined and washed away. This seems to be chiefly effected by land springs and other atmospheric causes; by which means the whole cliff is gradually set in motion, and slides down to be carried away by each succeeding tide. The destruction caused by this means is enormous, and taxes the full capacity of the engineer to combat its action.

2. THE SOUTHERN SIDE OF THE CARR NAZE AND BRIGG.

This shows the cliff on the southern side of the Carr Naze facing the bay, with the Brigg showing hazily in the distance towards the top right-hand corner. Owing to this view being taken nearly along the strike of the promontory it is much foreshortened, and the picture does not convey an idea of the length of the remarkable reef, which extends about half a mile beyond the extremity of these cliffs; these latter extend 700 yds. from the angle of the bay shown in the foreground, consequently the whole length of this headland is about a mile; while its breadth at the top of the cliff, in some places, is not more than a few yards. The cliffs shown in the picture are mainly composed of stiff Purple Boulder Clay with a few feet of Oolite rocks forming the narrow band at their base, which spread out on the foreshore in a succession of irregular layers.

The Boulder Clay here is remarkably hard and firm, so that it frequently forms vertical or overhanging cliffs. The effect of pluvial denudation is also very marked, the whole face of the cliff being ridged and furrowed in a most striking manner; this is well shown in the view, but perhaps rather more distinctly in the large photograph issued by the Society in April, 1895.

At the base of this great mass of Boulder Clay there are exposed a few feet of Oolitic rocks, which are the attenuated representative of the thick beds of limestone and grits so well shown inland along the northern margin of the Vale of Pickering.

3. The Western End of the same Cliffs.

We have here another view of these same cliffs seen from the shore, in the angle formed between the promontory and the bay. The effects of pluvial denudation in modelling the surface of the clay is here clearly shown; while the vertical faces of portions of the cliff, with boulders and large pebbles projecting from its surface, testify to its toughness and homogeneous character. Another curious feature are the sharp points that surmount the different ridges; these are usually capped by a small stone or pebble that for a time arrests the denudation.

On the left of the picture may be noticed a mass of clay that has broken off from the cliff behind it, and which before long will be carried away by the action of the waves. It is in this manner that the vertical faces of the clay are formed, and the more rapid wasting of the cliff takes place. Further in the bay to the south of this, where there are no protecting rocks at the base, the clay is constantly slipping down to the level of the water, and large portions are removed by every high tide. Consequently we see that it is this narrow band of rock at the base which has enabled these clays to withstand the action of the sea, and to form the remarkable projection of the Carr Naze.

These rocks are a portion of the Middle Calcareous Grit which forms the Brigg itself, while fragments of the Upper Limestone may be seen here and there beneath the clay. The strong southerly dip shown in the picture is continued across the promontory; so that on the other side, which is only 100 yards to the north, these Rocks form a considerable cliff, as shown in the following views, Nos. 4, 5, 6, and 7.

4. Northern Side of the Carr Naze, and Cliffs towards Scarborough.

This is a general view of the northern side of the promontory; It shows the small hollows or "doodles" into which the rock has been cut back so as to form a very irregular but picturesque coast line. The rocks shown here are representative of nearly the whole series of the Coralline Oolite. The great floors of rocks seen in the immediate foreground, and at the base of the cliff, are the upper part of the Lower Calcareous Grit; above this comes about 30 ft. of passage beds, very rich in fossils; while above this there are 10 ft. of gritty sandstone, and 6 ft. of alternations of shelly beds and sandstone, succeeded by the broken irrregular oolite of the Upper Limestone. On the left-hand side of the picture, in the dark part at the base of the cliff, there may be observed a peculiar nodular band. This is the famous dogger or ball bed at the top of the Lower Calcareous Grit, so well shown in the large photograph of the north side of Scarborough Castle Hill issued by the Society in 1883.

If the under surface of the great overhanging slabs of rock shown near the middle of the cliff be examined, they will be found covered with some peculiar branching forms which are supposed to have been cylindrical sponges, but their origin has not been satisfactorily proved. The whole of these upper flaggy beds are very fossiliferous, but from their great hardness it is difficult to procure good specimens.

5. One of the Coves on the North Side.

This shows one of the "doodles" or small coves mentioned above with its accompanying pool or bath. These doodles are one of the most curious features connected with these cliffs, and a remarkable instance of the peculiar manner in which marine denudation sometimes acts. There are four or five of these doodles along this part of the cliff, and they all occur at exactly the same geological horizon, that is, in the passage beds immediately over the ball bed of the Lower Calcareous Grit. These balls, which are excessively hard, are contained in soft sandy strata 10 ft. thick; consequently when they occur near the upper limit of the waves they are easily denuded, and the balls fall out. These are then rolled about by each succeeding tide, when they help to bombard the cliff and grind out the hollow or bath in the centre.

The small arch in the centre of the picture shows how these comparatively soft sands are more readily denuded, while the ominous crack that may be seen in the cliff above implies that it will not be long before a further portion of this cliff is removed.

6. Cliffs North Side of Carr Naze, looking N.W.

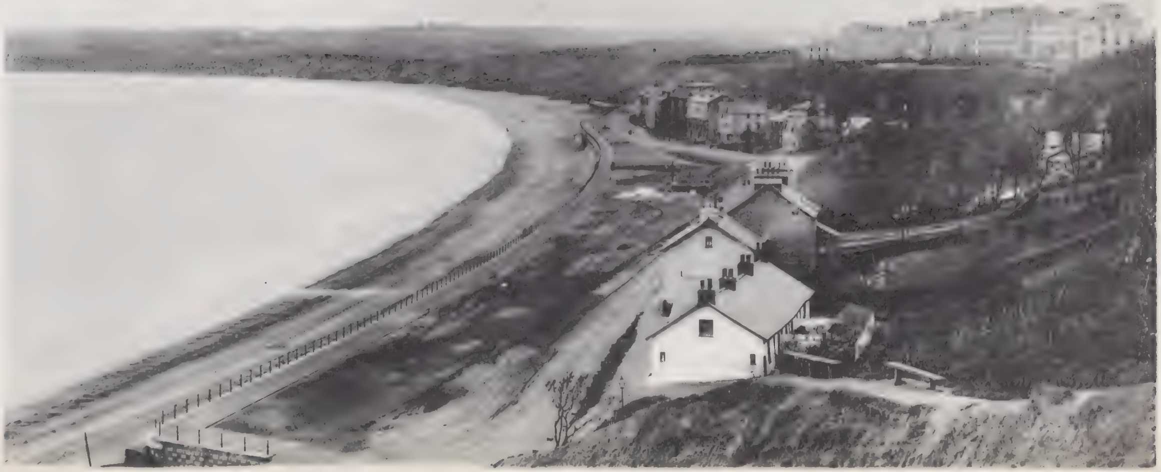
This is one of the most westerly of the "doodles" seen from above. In this view the higher beds are better seen. Their more rubbly character is here apparent, and contrasts very strikingly with the more massive beds shown in the previous views. One also observes that the overlying Boulder Clay is denuded into much flatter slopes, being washed down by the sheets of spray which pour over these cliffs during a northerly gale.

7. Cliffs North of Carr Naze, looking E.

This is the opposite side of the point shown in No. 6, and does not call for particular notice. The contortion of the rubbly limestone below the Boulder Clay is rather better shown in this view, as is also the indented character of the coast line.

8. Cliffs between Filey and Gristhorpe Bay, looking E.

This view is taken from the the projecting angle of Gristhorpe Cliff, near Cunstone Nab, looking S.E. towards Filey Brigg, which is dimly seen in the distance. The cliff here has an elevation of 250 ft. and shows the whole thickness of the Oxford Clay and the Lower Calcareous Grit with a considerable amount of Boulder Clay on top. The Passage Beds and Lower Limestone may be found here and there peeping out beneath the Boulder Clay, and were at



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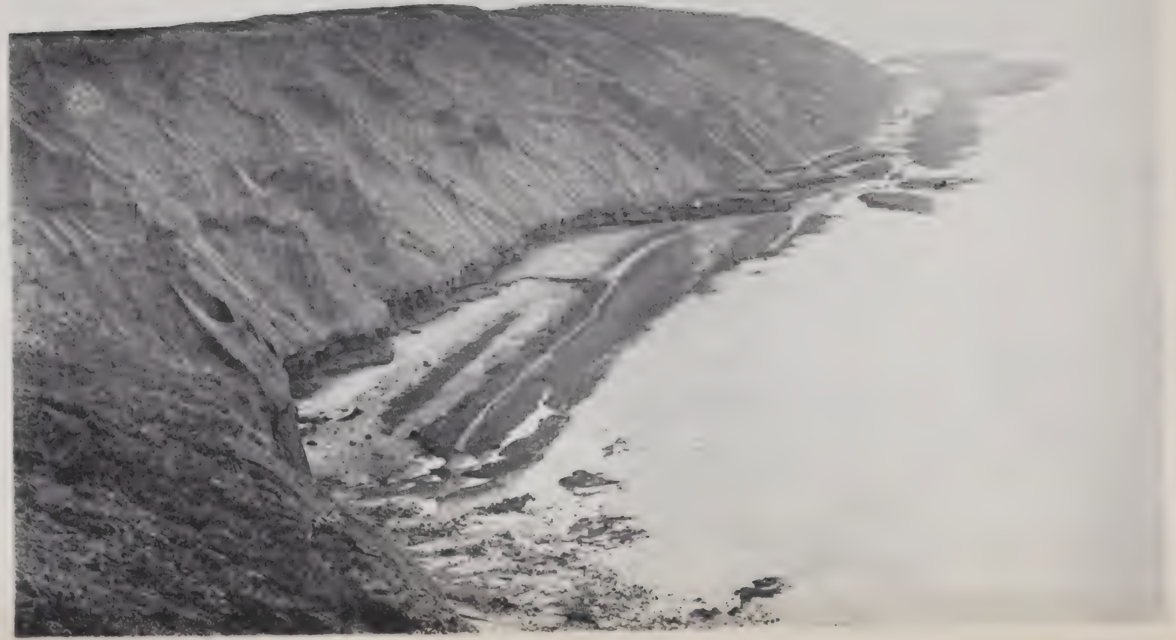
1. FILEY. TOWN AND BAY, LOOKING SOUTH.

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII., Plate XLIX.



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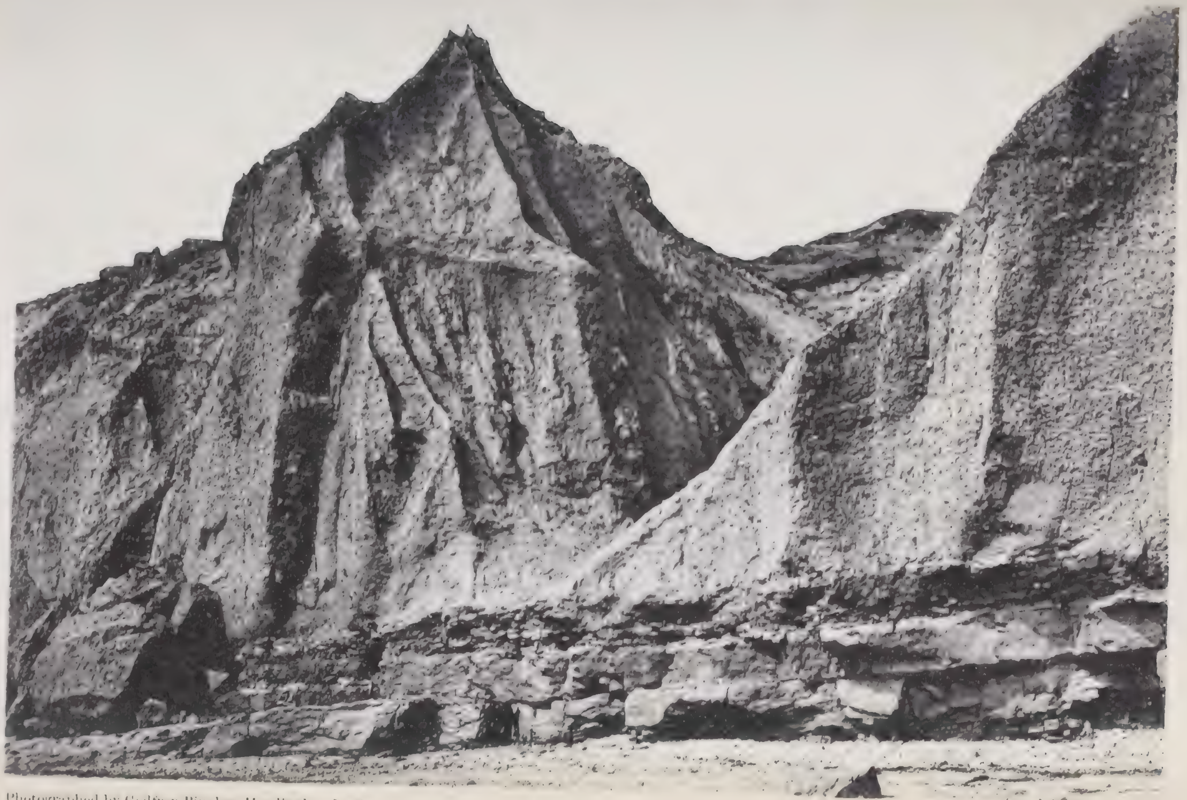
2. THE SOUTHERN SIDE OF CARR NAZE AND FILEY BRIGG.



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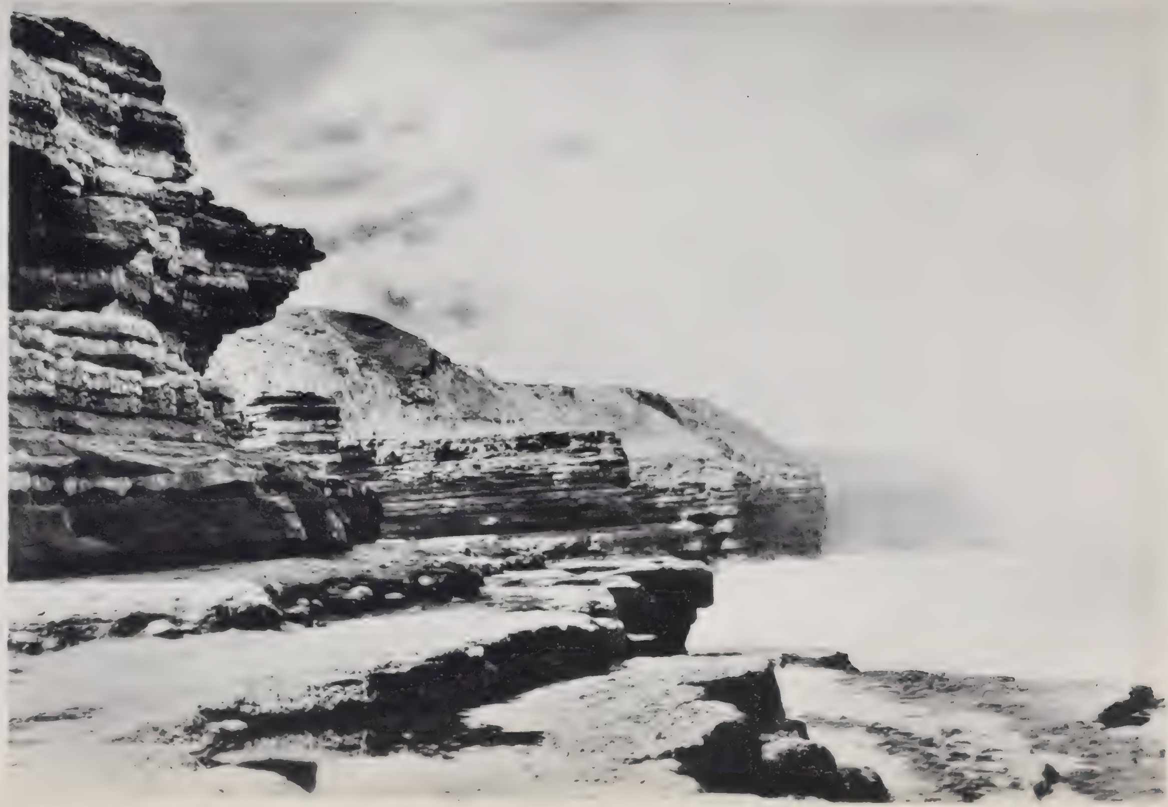
3. FILEY. WEATHERED BOULDER CLAY CLIFFS, CARR NAZE.

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII., Plate LI.



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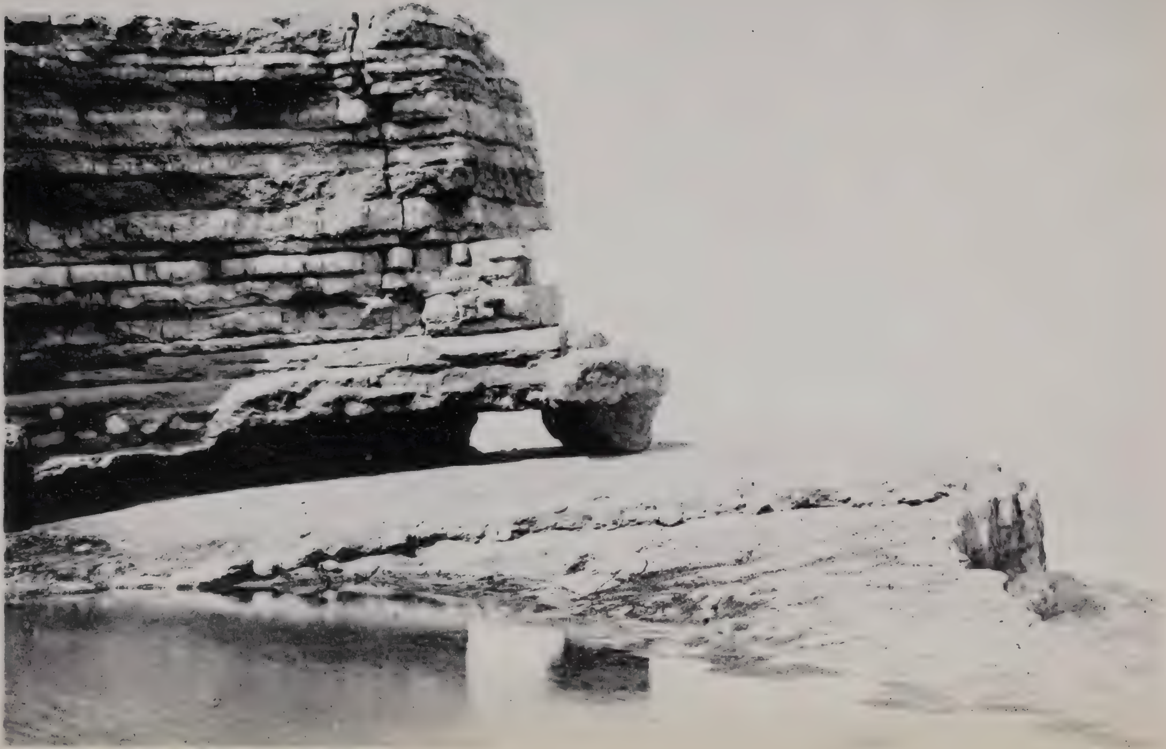
4. NORTHERN SIDE OF CARR NAZE AND CLIFFS TOWARDS SCARBOROUGH.

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII., Plate LII.



Photographed by Godfrey Bingley, Headingley, Leeds.

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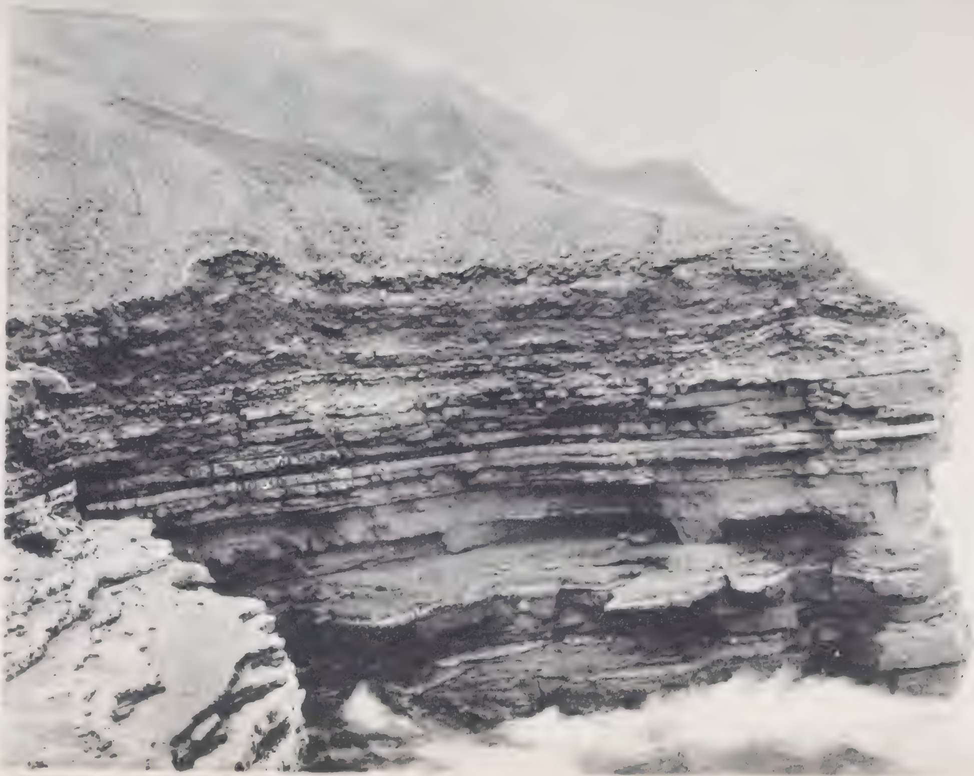
5. FILEY BRIGG. ONE OF THE COVES ON THE NORTH SIDE.



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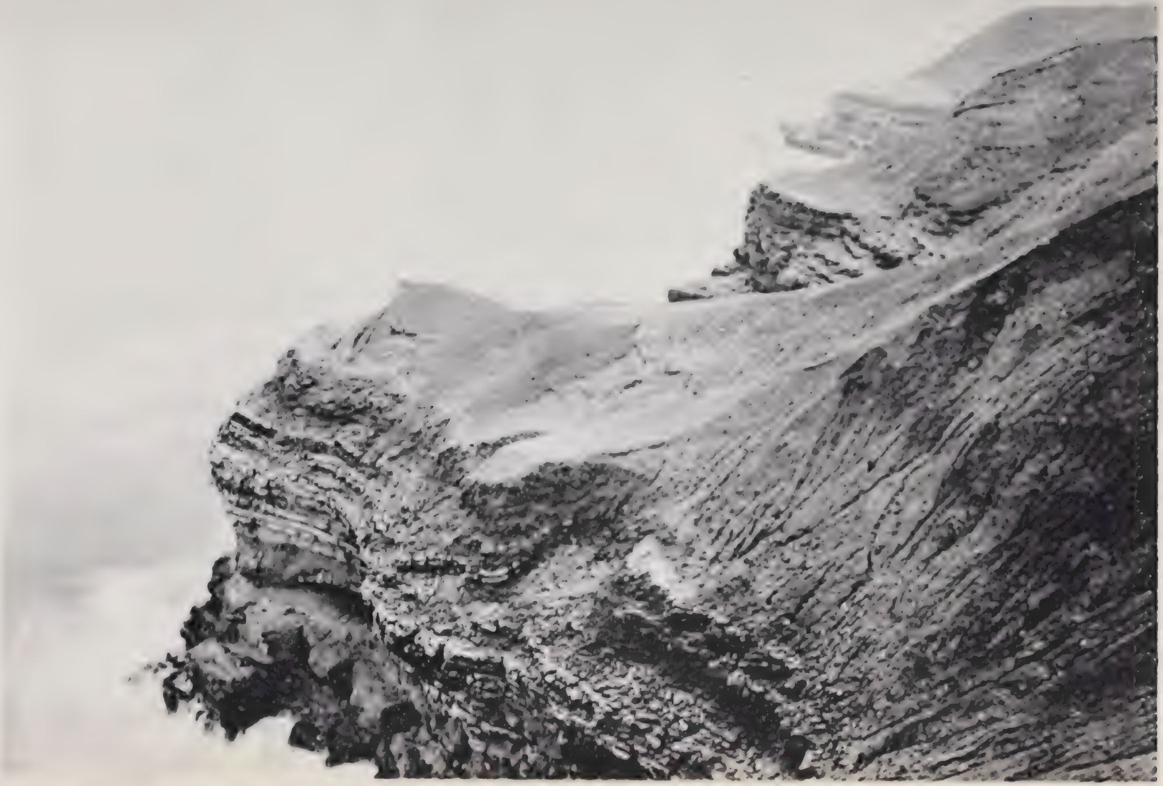
6. CLIFFS ON NORTH SIDE OF CARR NAZE, LOOKING NORTH-WEST.

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII., Plate LIV.



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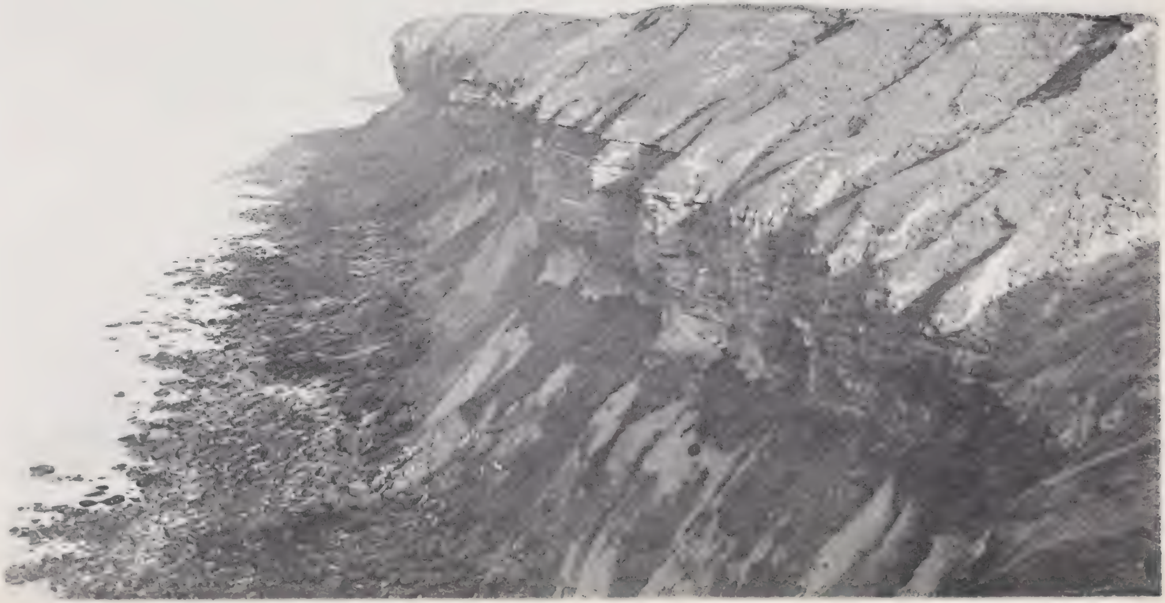
7. CLIFFS NORTH OF CARR NAZE, LOOKING EAST.

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII., Plate LV.



Photographed by Godfrey Bingley, Headingley, Leeds.

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8. CLIFFS BETWEEN FILEY AND GRISTHORPE BAY, LOOKING EAST.

Proc. Yorksh. Geol. and Polutec. Soc., Vol. XIII., Plate LVI.

one time burnt for making lime, but these beds being just at the top of the vertical part of the cliff they are not easy to examine.

On the shore, at low-water mark, close to the left-hand corner, the Kellaways Rock and Cornbrash may be observed when the tide is out, so that here we have one of the most complete sections of the lower part of the Middle Oolites in this part of the country. Most of the ammonites obtained from the Oxford Clay of Yorkshire have been found in blocks that have fallen from this cliff.

The contrast between the vertical and overhanging cliff of Calcareous Grit and the more gentle slopes formed by the Oxford Clay and Drift is well illustrated in this view. The numerous joints in the Calcareous Grit have caused the rock to weather into the buttress-like projections seen in this part of the cliff.

Before closing this short description of the rocks shown in Mr. Godfrey Bingley's excellent photographs, it may be as well to offer a few remarks on their geological history or the physical conditions under which they were laid down. During a portion of the period that immediately preceded the deposition of the rocks shown in these cliffs, there existed in this area a condition of dry land and large estuaries on which flourished the plant beds forming the coal seams of the Lower Oolite.

Towards the close of this period the land sank, more on this side than to the west, and the thin fossiliferous bed of the Cornbrash was laid down in a comparatively shallow sea, where in course of time its prolific fauna was overwhelmed by the great inrush of sands and sandy mud that formed the Kellaways Rock, here however probably reaching nearly their eastern limit. The source of these sands appears to have been from some ancient land away to the west of Thirsk, where the rock attains its maximum development, while the shales of the Oxford Clay above become very thin if they do not entirely disappear. The curious interlacing of these formations in the west leads to the idea that they are to a certain extent contemporaneous, and it is probable that the deeper water about Gristhorpe led to the deposition of the argillaceous beds of the Oxford Clay here, while more sandy beds were being formed nearer the shore line to the west.

After a time, probably from the gradual filling-up of this sea, sandy beds were again deposited, and the conditions became more favourable for the propagation of a marine fauna which throughout most of the higher rocks becomes tolerably abundant.

This was succeeded by a long interval of time, during which a great thickness of Upper Jurassic clays, Cretaceous, and possibly other rocks were formed. In course of time these were elevated above the sea and suffered extensive denudation, having been entirely removed from the area north of Filey before the commencement of the other great period we have evidence of in these sections.

As to the origin and age of the Boulder Clay there is considerable difference of opinion amongst geologists, but it is more generally conceded that it is the product of land ice in some form or other. Boulder Clay and other glacial deposits are found in considerable thickness all along the coast and down the great central valley of the county, while the interior moorland hills between are entirely free from any beds of this nature. It is therefore clear that these hills must have stood up above the sea of ice that surrounded them. From an examination of the stones included in the clay it is generally admitted that a large portion of the clay found in the Vale of York came from the western moorlands, while that of the coast is mainly derived from Scandinavia. The great ice-sheet which produced this clay must have ground against the coast with prodigious force, tearing up the large masses of shale that have been found at certain points, and piling up the ridges of sand and gravel that occur on the summit of the hills at Speeton and Irton, 600 ft. above the present level of the sea. By this means the drainage of the country was completely altered, all the streams flowing to the east being entirely dammed up and forced to cut for themselves new passages, as is so strikingly exemplified by the Derwent at Ayton and Malton.

On looking at these photographs it is interesting to notice the great variations in climate that have taken place during the formation of the rocks, showing temperatures ranging from the almost tropical seas that produced the corals in the limestone to the arctic cold that existed during the deposition of the clays immediately above them.

On the disappearance of the ice both marine and sub-aerial denudation again became very active, and the old bays and depressions of the coast, which had become obliterated by the clay, were carved out afresh to their present form. That this denudation is still rapidly going on there is abundant proof, some parts of the coast being stated to waste as much as from 2 to 4 yards in the year, so that in course of time Filey Bay may be enclosed by lofty cliffs of Chalk and Oolite with a small tidal river entering the sea between its shores.

A GLACIATED SURFACE AT FILEY.

BY JOHN W. STATHER, F.G.S.

Notwithstanding the enormous development of glacial deposits in East Yorkshire, glaciated rock surfaces were until recently comparatively quite unknown. The chief reason for this is no doubt the lithological character of the Secondary strata, which constitute the solid geology of this part of the county. The soft shales and sandstones, of which the Jurassic rocks chiefly consist, could not be expected to stand sufficiently firm under the pressure of the ice-sheet to receive such markings, nor yet to preserve them if by any accident such impressions had been made. The same remarks apply to the Cretaceous rocks, although some of the indurated layers of the Chalk with flints might possibly have taken striæ, had the local conditions of glaciation been favourable.

Almost the only rocks on which there was any probability of these markings being preserved are the harder limestones of the Middle Oolite, and the ironstone bands of the Lower Oolite and Lias; and it is precisely on these rocks that such markings have at length been found.

The first discovery was that recorded by Mr. G. W. Lamplugh in the "Proceedings" of this Society in 1891,* where he mentions that the highest bed of the Oolite series of Filey Brigg showed glacial striations having a direction N. 20°E. These markings occurred at the south side of the Carr Naze, at the spot where the solid rock disappears from the coast line under the drift, a few yards to the left of the section in plate LI.

In 1896 Messrs. Sheppard and Muff recorded in the Glacialist's Magazine† similar striations on a surface of Estuarine Sandstone exposed in a quarry north of Robin Hood's Bay, the direction of the striations being given as due north and south.

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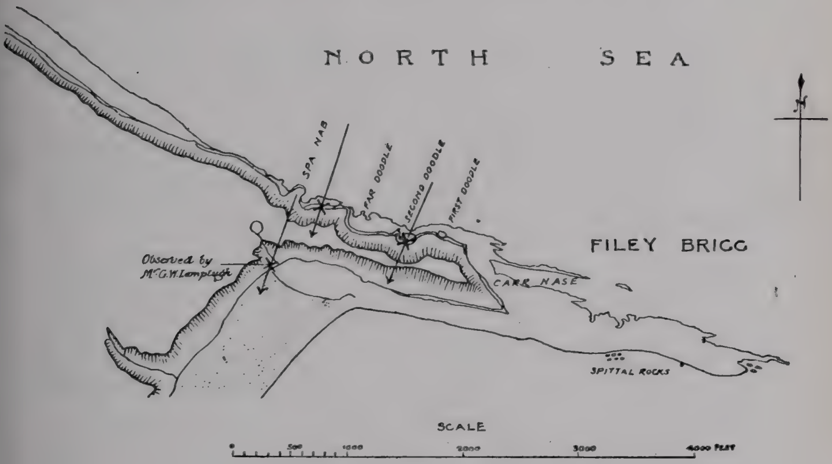
* Vol. XI., Part iii., page 401.

† Sept., 1896, pages 52, 53.

Numerous instances of well-marked terminal curvature and superficial contortion of the solid strata, undoubtedly due to glacial action, have been noted on the Yorkshire coast, and recorded by many geologists; this evidence confirming that of the striæ, as regards the direction of the movement of the ice.

To the above examples we are now able to add a further instance, on a more extended scale, in the vicinity of those already described, near Filey Brigg. The surface described by Mr. Lamplugh is rarely visible, being usually hidden under slip from the high cliff of drift above it. But on the other side of the promontory (see plates LII., LIV., and LV.), I have found that the prolongation of the same rock surface in that direction, as seen in the ledge of rock above the picturesque shallow caves known as the "Doodles," is distinctly glaciated over a considerable extent. The irregular concretionary knobs, which stand up above the general plane of bedding, perhaps show the markings the best; but they can also be traced more or less clearly along the rocky ledge immediately below the drift, for a distance of at least 400 yards.



A group of striæ is visible near the western end of the glaciated surface, immediately east of the Spa Nab (plate LIV.); and the directions of the striæ at six points a few yards apart, are as follows:—(I.) N. 15°E., (II.) N. 15°E., (III.) N. 10°E., (IV.) N. 30°E., (V.) N. 15°E., (VI.) N. 25°E.; giving a mean direction of N. 18°E.

Two hundred yards eastward of the foregoing group, near the second "Doodle" (plate LV.), at four points twenty yards apart, the striæ read thus:—(I.) N. 20°E., (II.) N. 30°E., (III.) N. 20°E., (VI.) N. 25°E.; mean direction N. 24°E.

It will thus be seen that the general direction of the striæ agrees closely with the direction noted on the south side of the Brigg by Mr. Lamplugh. It is also worth noting that the mean direction of the eastern group (2nd Doodle) is six degrees more to the east of north than the mean direction of the western group (Spa Nab).

The striated surface is about 40 feet above high-water mark, and dips three or four degrees to the south-east. The overlying drifts are 70 feet thick, and consist of boulder-clays of the type usual on the Yorkshire coast (plates L. and LI.).

Where the striæ are seen there is a complete absence of the local rock rubble, which usually intervenes between the boulder-clay and the solid strata, and which is so abundantly developed in most of the adjacent sections. It is evident that for some reason or other the pressure of the ice-sheet at this place was sufficiently great to sweep away all the loose weathered material, and thus to reach the hard unbroken calcareous band on which the markings are preserved.

Further evidence of the exceptional pressure exerted in this locality is furnished by the sections a few yards to the west of the striated surface (plates LIV. and LV.), where the beds are superficially contorted to a depth of eight feet.

The reason for the extra pressure at this place may, I think, be readily explained. The high ridge formed by the Middle Oolites to the north (plate LVI.), which would necessarily constitute a barrier to the movement of the ice, sinks down at this point low enough to permit access to the wide pre-glacial depression of the Vale of Pickering. And the great mass of the drift deposits which now blocks the mouth of this valley shows clearly by its character that a tongue of ice passed inland at this point for some distance. The striæ are close to the place where the great inland curve would occur, and where, therefore, considerable augmentation of the pressure in the basal layers of the ice might be expected.

For the map illustrating these notes I am indebted to my friend, Mr. W. H. Crofts.

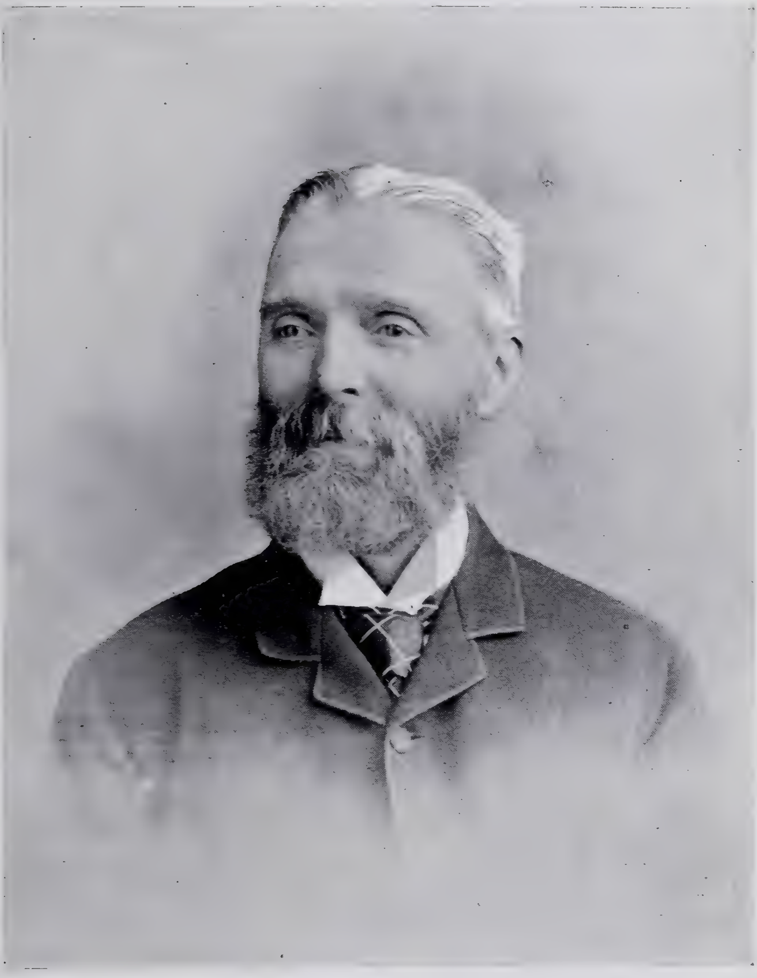
In Memoriam.

THOMAS TATE, F.G.S.

Among the losses sustained by our Society during recent years, none has been more sincerely felt than that of our valued friend and co-worker, Mr. Thomas Tate, F.G.S. For many years Mr. Tate was a consistent supporter of our Society, and one of its most active workers. He was elected a member in the year 1875, and, on the appointment of Local Secretaries to assist the General Secretary, Mr. Tate became Local Secretary for the Bradford District with a seat on the Council, retaining this position until October, 1894, when he resigned in favour of the present Local Secretary, Mr. J. E. Wilson. At the Annual General Meeting, held at the Grammar School, Bradford, on November 7th, 1894, Mr. Tate was elected on the Council to fill the vacancy caused by the retirement of Mr. C. Fox-Strangways, who had left Yorkshire, and this position he held until his decease.

Mr. Thomas Tate was a native of Leeds, having been born there in 1833. After leaving school, at fourteen years of age, he entered the warehouse of Messrs. A. & S. Henry & Co., and continued with that firm on their removal to Bradford, remaining in their employ until he commenced business for himself in the stuff trade, when about thirty years of age. During a period of bad trade in Bradford, when many large firms of stuff and wool merchants failed, he closed his warehouse and disposed of his stock.

For many years he had devoted much of his leisure to scientific studies, including botany, entomology, and geology, attending evening classes for instruction. He was also an early member of the Bradford Scientific Association, of which he was Vice-President when the first series of Gilchrist lectures was given at Bradford. He also gave a series of lectures on Geology to the members, and conducted several excursions to places in the Bradford basin, with the principal geological features of which he had become thoroughly acquainted, as well as with those of the upper valley of the Aire. He also conducted excursions for the study of pond life, and con-



Yours truly
Thomas Tate

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tributed to the 'Naturalist' an excellent paper on the organisation of the Water Flea (*Daphnia pulex*) in 1875.

In 1879, in conjunction with Mr. Walter Morrison, of Tarn House, Malham, and several members of the Yorkshire Geological and Polytechnic Society, he conducted an investigation of the sources of the River Aire, tracing the water from Malham Tarn to the springs at Airehead, and the stream issuing from the base of the cave, by opening the sluices of the Tarn and flooding the intervening district containing swallow holes through which the water escapes, and observing its re-appearance. Acting as Secretary for the party, he prepared a report of the investigations, which was read before the Society and published in the Proceedings, along with a second paper on an intermittent spring at Malham.

On retiring from business Mr. Tate resolved to devote himself to scientific study and teaching, and in order to become thoroughly prepared for the work he took several courses of instruction at the Royal School of Mines, etc., South Kensington, and at the Yorkshire College, Leeds. For some time he conducted a geological class at the Bradford Mechanics' Institute, which was the means of inclining many young men to pursue a course of geological study. On returning to reside in Leeds, he became a popular and successful teacher of science. He had classes at Bradford, Harrogate, Leeds Mechanics' Institute, Ampleforth College, Malton, Dewsbury, Barnsley, and other Yorkshire towns. His subjects were chiefly Biology, Botany, Physical Geography, and Geology. He was a diligent, thoughtful, and ardent student, and a kind and painstaking teacher, endeavouring to interest as well as instruct his pupils, by whom he was generally loved and respected.

In November, 1891, he was appointed Secretary to the Yorkshire Boulder Committee, in succession to the late Mr. S. A. Adamson, F.G.S. Soon after being appointed Secretary he was commissioned by the Committee to visit the Lake country to examine its physical and geological features, and to collect such specimens of the rocks of the district as would enable students to identify boulders from them found in any part of the country. Numerous specimens were collected and labelled on the spot, and afterwards sections were carefully prepared for the microscope.

In addition to his numerous classes he was always ready to give a helping hand to local scientific societies. In connection with the Leeds Geological Society, for instance, he conducted excursions to several places of geological interest, and wrote papers on Petrology and other geological subjects for their monthly meetings.

The following papers were contributed to our Proceedings by Mr. Tate:

"The Glacial Deposits of the Bradford Basin" (1875);
"The Source of the River Aire" (1879);
"Note on an Intermittent Spring at Malham" (1879);
"Yorkshire Petrology, Part I." (1888);
"Yorkshire Petrology, Part II., The Lamprophyres" (1889);
"On the So-called Ingleton Granite" (1891); and
"The Malham Dry River Bed" (1896).

His last contribution to Geology was a paper on "Yorkshire Petrology, Part III, Analyses," which he read in abstract at the Annual General Meeting of our Society, held in the Town Hall, Wakefield, on Thursday, October 29th, 1896. The last communication received from him by the Hon. Secretary was a promise to prepare this paper for the press, but as no finished manuscript has been found amongst his papers, it is evident that his sudden and unexpected death prevented him from completing this work.

He was a man who had a passion for hard work, and was constantly busy. He was noted for conscientious and careful investigation, and was much respected for his uniform uprightness of thought and life. He had a considerable influence over young men, and always impressed those who came into contact with him, with the honesty of his convictions and with his firm courage in maintaining them. He attended his classes to within a few days of his death, and though his health had been failing for some months, the end came with unexpected suddenness, and was a great shock to a large number of friends and pupils by whom he was greatly esteemed. He passed away at his residence, Eldon Mount, Leeds, on April 27th, 1897, aged 65 years, and was interred at Woodhouse Cemetery.

W. L. C.

In Memoriam.

JOHN STANLEY TUTE, B.A.

The Rev. John Stanley Tute, B.A., late vicar of Markington, was born at Wakefield, on the 21st April, 1823, and died at Markington, on the 24th December, 1897.

Owing to the early death of his mother, and to the fact that his father (after a second marriage) had gone out to Australia as a schoolmaster, young John Stanley was left to the care of a relative, Miss Stanley, of Leeds, under whose kind, but somewhat austere tutelage, he passed his earlier years. Ultimately he was sent to the Moravian School at Fulneck, and when he left that institution, was persuaded to go into the cloth business. Not having any taste for this occupation, he went up to St. John's College, Cambridge, where he took his B.A. degree in 1846, coming out in honours. That same year he married, and was ordained deacon. He was ordained priest at Ripon in the following year, and in 1849 was appointed to the newly-constituted vicarage of Markington.

For 48 years he discharged the duties of a parish priest in the same village, and during this long period endeared himself to more than one generation of parishioners. His studies also turned in the direction of poetry and painting, but his special forte was woodcarving, in which he had considerable skill and excellent taste. To his skill the Church at Markington owes its reredos, chancel screen, pulpit, and font cover. He was the author of two devotional works, "Holy Times and Scenes," and "Meditations on the most Precious Blood and Example of Christ."

It is not our purpose, however, to speak of him as a clergyman, but rather as one interested in science, and in the observation of nature.

Mr. Tute was a man of refined and cultivated tastes, no mean artist in his way, and ever ready to impart his information to others. His daughter tells us that he was in the habit of giving lectures in the village school-room on various scientific subjects, the most popular being "The use of little birds to the farmer." He also kept a weather chart for many years, and was a very true weather prophet; in fact, the parishioners consulted him anxiously before they cut their hay. He was also instrumental in obtaining a supply of good drinking water, conveyed in pipes, which has for some years been of great benefit to the village.

Though acquainted with more than one science, Geology was his favourite study.

For many years he was a member of the Yorkshire Geological and Polytechnic Society, and also of the Ripon Scientific Society. To the former he made several communications which prove him to have been one of the best local geologists in that part of the West Riding.

The discovery of a fossiliferous horizon in the hitherto barren Millstone Grit series was due to his innate aptitude for fossil-hunting, in combination with his topographical knowledge of the picturesque neighbourhood of Markington, where the Cayton Gill beds were first made known. This horizon has since been proved to underlie the Plompton Grit in all parts of the district, and has been of considerable use in mapping the country. In most places the rock is a hard calcareous sandstone, full of the remains of Encrinites, *Producti* and other Brachiopods, which has been largely quarried for road metal at many points to the west of Harrogate and Ripon. Subsequently Mr. Tute recorded the discovery of *Spirangium carbonarium* from a boulder in the Drift, which he regarded as having been derived from the Yoredale series. About the same time he noted the occurrence of *Lingula* in the Millstone Grit series to the west of Ripon, the first recorded from beds of that age in the district.

The Magnesian Limestone of this part of Yorkshire has, also, the reputation of being very barren hunting-ground. Yet Mr. Tute was able to compile a very good list of Permian fossils* from the Lower Limestone of Aldfield and Well. In 1883 he gave an

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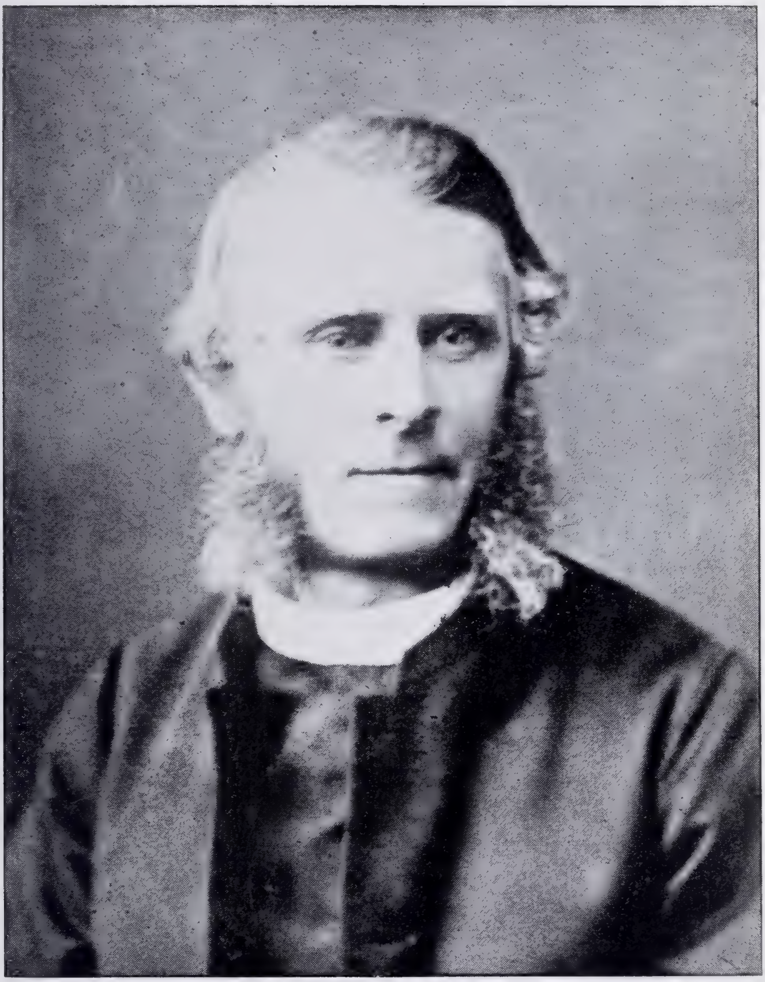
* Quoted by Mr. Fox-Strangways in the Survey Memoir of the Country north and east of Harrogate, p. 10.



John Stanley Tute

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII., Plate LVIII.

interesting account of the sequence of the Permian rocks near Ripon, with sections showing the development of the beds at Wormald Green, Quarry Moor, and in the valley of the Skell, east of Fountains Abbey. In the old quarry near Wormald Green he discovered a fossiliferous horizon towards the base of the main limestone which yielded him some interesting specimens. Indeed, it is not too much to say that most of our knowledge of the irregular and variable Permian beds of the Ripon district is due to the keen perception and enthusiasm of Mr. Tute.

For the last few years, unfortunately, he was in failing health, and unable to indulge in his favourite pursuits as formerly. The death of his wife in 1894 was a great shock to him, and getting gradually weaker he died peacefully last Christmas Eve in his 75th year.

W. H. Hudleston.

Papers by the Rev. J. Stanley Tute, B.A., Published in the Proceedings of the Yorkshire Geological and Polytechnic Society.

"On an Orthoceras of the Millstone Grit" (1878).

"On the Sequence of the Permian Rocks, near Ripon" (1883).

"Some indications of a Raised Beach at Redcar" (1883).

"On the Cayton Gill Beds" (1886).

"Note on the occurrence of Lingula in the Millstone Grit Series, West of Ripon" (1887).

"Notes on some singular cavities in the Magnesian Limestone" (1889).

"A Permian Conglomerate bed at Markington" (1892).

"On some singular nodules in the Magnesian Limestone (1893).

"The occurrence of the tooth of a Mastodon in the Glacial Drift" (1893).

NOTES ON THE COAST SECTIONS BETWEEN HAYBURN WYKE AND FILEY.

BY C. FOX-STRANGWAYS, F.G.S., OF THE GEOLOGICAL SURVEY.

(Prepared for the Field Excursion to Scarborough, July, 1897.)

The area to be visited during this Field Excursion consists entirely of beds belonging to the Middle and Lower Oolites. To the north of Hayburn Wyke are the Staintondale Cliffs, which are composed entirely of the Estuarine Series of the Lower Oolite, with the three marine divisions of the Eller Beck Bed, the Millepore Bed, and the Grey Limestone Series. The marine bands of the Millepore Beds and the Grey Limestone come to the shore on either side of Cloughton Wyke, where they form conspicuous reefs, which can be examined at low water. Between this point and Scarborough the coast is formed by the sandstones of the Upper Estuarine Series.

At Scarborough the Middle Oolites first reach the coast and form the bold and prominent headland of the Castle Hill. This may be considered as one of the typical Oxfordian sections, nearly the whole of this series being exposed in a vertical cliff 250 feet in height. The summit of this cliff, with the exception of a thin covering of Boulder Clay, is capped by about 20 feet of Oolitic Limestone, representing the lower part of the Lower Limestone; below this comes about 37 feet of Passage Beds very full of a small *Ostrea*, *Gervillia aviculoides*, and *Pecten subfibrosus*. These rest on 18 feet of soft sands with large calcareo-siliceous concretions forming the upper part of the Lower Calcareous Grit, the lower beds of which pass gradually down into the sandy shales of the Oxford Clay.

By a fault which passes close to the entrance to the Castle the Kellaways Rock is thrown up on the west side, and a fine section of these sandstones, here about 80 ft. thick, is exposed in the North Cliff. The Cornbrash is seen at places beneath this rock, while the lower part of the cliff is occupied by the shales and sandstones of the Estuarine Series.

South of Scarborough the Grey Limestone occupies the shore as far as White Nab. It consists chiefly of grey calcareous shales with nodular bands, in which *Gervillia acuta*, *Ostrea flabelloides*, *Avicular braamburiensis*, and other fossils are very abundant. In the Scarborough Museum are some of the bones of *Cetiosaurus*, obtained from these shales. Between White Nab and Osgodby Nab the shore is occupied by the sandstones of the Estuarine Series, but at the latter point a large fault has brought up the Millepore Bed, which is well exposed in this headland, and contains the characteristic bryozoan *Cricopora (Millepora) straminea* in great numbers on the surface of the rock.

We now enter Cayton Bay, on the south side of which is the magnificent section of Red Cliff. Here nearly the whole of the Oxfordian beds are again exposed in one of the grandest sections of the Yorkshire Coast. At the top the Lower Calcareous Grit rises in a beetling crag, beneath which the Oxford Clay forms a somewhat less precipitous slope, the Kellaways Rock occupying the base of the cliff, while the Cornbrash forms a ledge on the shore. The altitude of this cliff is over 250 feet, of which 120 feet are included in the Oxford Clay, and 35 feet in the Kellaways Rock. At the eastern end of this cliff a fault, having a throw of 120 feet, brings up the Lower Oolite, so that the Grey Limestone and Millepore Bed crop out on the shore, and may be followed along the scars throughout Gristhorpe Bay. The Grey Limestone is here reduced to about 3 feet in thickness, and may be easily overlooked; but the Millepore Bed is a strong massive rock, forming the outer part of the scars, and protecting this part of the coast from the force of the waves. Between these two the celebrated plant bed of Gristhorpe occurs, beneath which are some thickness of beds of a semi-estuarine character which are not known to occur elsewhere. The cliffs of Gristhorpe Bay show exposures of the Kellaways Rock and Cornbrash, the former much reduced in thickness.

SECRETARY'S REPORT, 1897.

It is a pleasure to be able to report another year of successful work. The General Meetings have been associated with interesting and valuable Field Excursions, and the weather was so propitious on each occasion as to enable the programme to be completely and successfully carried out.

The Spring General Meeting was held at Pateley Bridge, on Saturday, May 22nd, and was associated with an Examination in the field of the chief geological features of Nidderdale. The Harrogate Local Secretary, Mr. Robert Peach, being away on the Continent, the local arrangements were kindly undertaken by Mr. John Farrah, F.R.Met.S., who also undertook the general leadership of the party. The Members met at Harrogate Station and travelled together to Ripley Valley. A large quarry in the Millstone Grit, near Killinghall Mills, was first examined, and then the old course of the Nidd, from which it was artificially deflected some centuries ago, was pointed out by the leader. A visit was then paid to Ripley, the Church and old stocks being inspected, after which, the road was taken to Hampsthwaite quarries, where the Cayton Gill beds are worked. These beds were found to be full of fossil remains, chiefly casts. From Hampsthwaite Station the train was taken to Dacre, where luncheon was served. Wagonettes then conveyed the members to the breezy heights of Brimham Moor, where some time was spent in the investigation of the remarkably denuded Millstone Grit rocks and enjoying the pure air and wide views. During a discussion on the spot of these extraordinary rock-forms and the mode of their production, the impossibility of attributing the denudation of these rocks to marine agency was pointed out, the levels of the various denuded beds being so different, and the results so unlike a cliff-line with isolated pinnacles. No other agency than that of atmospheric weathering could account for all the facts. As to whether denudation was continuing the same work now, Mr.

Percy F. Kendall pointed out that the evidence was not in favour of this view. He was more inclined to believe that present denudation was slowly destroying the unusual shapes of these rocks, and bringing them to more ordinary types of weathering. He suggested that the evidence was in favour of Brimham Rocks being the result of a special and very severe period of denudation, and was inclined to attribute their formation to the extreme conditions of the glacial period operating on the out-cropping sandstones of the moor. From the moorland, a cross country traverse was taken to Smelt House, and the road followed to Pateley Bridge. The members dined together at the King's Arms Hotel, under the presidency of Edward Yorke, Esq., J.P., of Bewerley Hall, and afterwards the General Meeting was held. An address on the Mining and other interesting features of Nidderdale, was given by the Chairman, and Mr. Percy F. Kendall delivered an address on "The later Physical History of the River Nidd," which opened up an interesting discussion. A resolution of sympathy with Mrs. Tate, on the death of Mr. Thos. Tate, F.G.S., a member of our Council, and formerly Local Secretary for the Bradford district, was passed. Several of the members expressed deep regret at Mr. Tate's sudden death, and references were made to his wide scientific knowledge and accurate work, and especially to his important work as Secretary to the Yorkshire Boulder Committee.

By the kind invitation of the Chairman (Edward Yorke, Esq.), the members paid a visit to Bewerley Hall on Sunday afternoon, and were shown over the gardens by Mr. and Mrs. Yorke. Bewerley Hall was erected on the site of a grange formerly belonging to the Monks of Fountains, and the small chapel at the back of the hall was pointed out, which bears the initials of Marmaduke Huby, Abbot of Fountains (1494-1526) and the motto: "Soli deo honor et gloria." Mr. Yorke then conducted the party through the Fishpond Wood to Raven's Gill, a beautiful little gorge formed by Raven's Beck. At the top of the gill the beck was crossed and several of the members climbed the moorland path to Guy's Cliff, from which a fine view of Nidderdale was obtained. Various picturesquely weathered rocks were noted, and a return was made to Pateley by way of the richly-wooded undercliff.

On Monday morning wagonettes took the party to Upper Nidderdale. Short stops were made to inspect the works for the compensation reservoir of the Bradford Corporation, and to view Gouthwaite Hall, a seventeenth-century house, the old residence of the Yorkes, which will probably be destroyed by the new reservoir. Near Lofthouse one of the water gushes by which the Nidd emerges from its underground course was examined. From Lofthouse the dry valley was followed up to Goydon Pot, where a short stay was made, and then a visit was paid to Manchester Pot, into which, at the time of our visit, the whole of the waters of the Upper Nidd were discharged. Ascending the hill to Middlesmoor a short cut was taken to How Stean Beck, and the beauties of this wonderful little gorge were duly admired. For the last mile before joining the Nidd, How Stean Beck rushes through a narrow cleft in the Yordale Beds, 70 feet deep, and forms a ravine which is a picturesque illustration of torrent denudation. The sides of the gorge are hung with mosses and ferns, and overshadowed with trees. Eglin's Hole, a chasm on the south side of the ravine, was also explored. The return journey was made by wagonette to Pateley Bridge.

The Summer General Meeting was held at Scarborough, on Friday, July 9th, and was associated with Field Excursions in the neighbourhood on Thursday, Friday and Saturday. On Thursday, July 8th, the members united with the geological section of the Yorkshire Naturalists' Union in an excursion to Hackness. The party were conveyed by wagonettes to Suffield Heights, where a quarry in the Coral Rag was examined. The route was continued by Hackness Hall to Silpho, where quantities of a large gasteropod (Phasianella) were found. Rejoining the conveyance at Hackness, the party drove down Forge Valley to Ayton quarries in which masses of Thamnastræa were found. Thence the road by the race course was taken to Scarborough.

On Friday morning the party met at Castle Hill, under the leadership of the Rev. E. Maule Cole, and examined the Calcareous Grit Beds, and the works in progress for the safeguarding of the new marine drive. The 11.15 train was taken for Gristhorpe, a cross-country walk bringing the party to the cliffs, several heaps of boulders being carefully examined on the way. Excellent views of Filey Brigg and the Chalk cliffs from Speeton to Flamborough were obtained from the cliff top. A descent was then made to the shore and the splendid sections from Gristhorpe to Scarborough were carefully examined.

The members dined together at the Pavilion Hotel, and after dinner the General Meeting was held under the presidency of the Rev. E. Maule Cole, M.A., F.G.S. Several members of the Scarborough Field Naturalists' Society were welcomed as visitors. A valuable gift from Mrs. A. H. Green, through Mr. William Whitaker, F.R.S., F.G.S., of six-inch geological maps from the library of the late Professor Green was reported. The Chairman expressed warm appreciation of this kind donation, and the very hearty thanks of the Society were accorded to Mrs. Green for her useful and valuable gift. The Chairman then delivered an address on the Geology of Scarborough and district, describing in a genial and clear way the chief geological features of the neighbourhood, enlarging on the evidence for the diversion of the Derwent and other interesting problems of the physical geography of the East Riding. A discussion followed, in which the problems opened out by the consideration of river-diversion and the theory of river-capture, as applied to the Humber and its tributaries, were vigorously discussed.

On Saturday morning another visit was made to the Castle Hill sections, under the leadership of Messrs. J. W. Stather, F.G.S., and George Lether. The 12.10 train was taken to Cloughton, where the party was swelled by a number of Scarborough naturalists. The exposure of Grey Limestone at Hundale was first examined, and characteristic fossils obtained. Returning to Cloughton, the shore route was taken to Hayburn Wyke, the exposures of the Millepore Beds and the Ellerbeck Bed being examined. The party returned to Scarborough by train.

By the kind invitation of Mr. Percy F. Kendall and the members of the Glacialists' Association, the members of our Society were enabled to take part in an interesting and instructive Field Excursion at Easter, to Appleby and District. The party assembled at Appleby on Thursday, April 15th. On Good Friday a drive was taken to Shap under very watery conditions, but the weather cleared up sufficiently to enable a visit to be paid to the famous granite quarries, which were examined with much interest. A long traverse over the moors, several dykes being examined on the way, brought the party to Shap Wells, where a Basement Carboniferous conglomerate was found containing pebbles of Shap granite. On Saturday, High Cup Nick was visited in a drizzling mist, and the Whin Sill carefully examined. On Easter Monday the party visited the Upper Stainmoor Pass and a Shap boulder was found close to the summit. On Tuesday the interesting sections revealed by Swindale Beck, and the quartz-porphyry called ' Dufton Granite,' were examined. Altogether the excursion was full of interest and valuable information to students of Yorkshire Geology.

In connection with the meeting of the Sanitary Institute in Leeds, on September 14th, the Society was requested to appoint two delegates to the Congress. Mr. J. E. Bedford and the Hon. Secretary were accordingly elected to represent this Society. Several interesting papers were read in the Geological and Chemical Section on the relation of the rock-beds to Sanitary Science, and a valuable resumé of the facts regarding the strata of Yorkshire in relation to its water-supply was given by one of our members, Mr. Percy F. Kendall, F.G.S.

At the Annual General Meeting at Wakefield last year, five new members were elected, and at the Pateley Bridge meeting ten new members were added to the list. We have very regretfully to record the loss of three members by death, Mr. E. B. Wheatley Balme, J.P., of Cote Hall, Mirfield, who has been a member since 1875; Mr. Thomas Binns, of Sawley Hall, Ripon; and our lamented friend and co-adjutor Mr. Thomas Tate, F.G.S. With the addition of the names of three gentlemen to be submitted to this Annual Meeting for election, the roll of membership now stands at 164, which is the highest since 1893, and it is satisfactory to know that all the members now on the roll are in active association with the Society.

The Proceedings, Vol. XIII., Part 2, was issued to the members in the month of August, and will, the Editors believe, be found equal in interest and value to any preceding issue. Special mention may be made of the beautiful series of collotype re-productions of Mr. Godfrey Bingley's photographs of the Chalk of Flamborough Head, and the Council have much pleasure in announcing that they will be followed in 1898 by a series illustrating the Middle Oolites of Filey Brigg, also from Mr. Bingley's negatives.

In accordance with a more usual, and it is thought, advisable custom, the Editors have dated the proceedings published in 1897 with the year of issue, instead of dating it a year back as has been the custom latterly. This looks apparently, as if the year 1896 had been missed, but the part dated 1897 contains the records of the year 1896, and, under the previous system, would have received that date.

The Proceedings of the Society have been sent, as usual, to leading Scientific Societies in various parts of the world, and your Council desire to acknowledge their indebtedness to the undermentioned Societies for the kind gifts of their publications for our library, in exchange for our Proceedings.

Royal Geological Society of Cornwall, Penzance.
Royal Physical Society of Edinburgh.
Royal Geographical Society, London.
British Association, London.
Geological Society of London.
Bristol Naturalists' Society.
Cambridge Philosophical Society.
Essex Naturalists' Field Club.
Leeds Literary and Philosophical Society.
Liverpool Geological Association.
Liverpool Geological Society.
Manchester Geological Society.
Manchester Geographical Society.
Manchester Literary and Philosophical Society.

Geologists' Association, London.
Glacialists' Association, Leeds.
Hertfordshire Natural History Society.
Hull Geological Society.
Rochdale Literary and Scientific Society.
Warwickshire Natural History and Topographical Society.
Yorkshire Naturalists' Union.
Comité Geologique de la Russie, St. Petersbourg.
Naturhistorischen Hofmuseum, Wien.
Kaiserliche Leopoldinisch-Carolinische Deutsche Akademie des Naturforscher, Halle-a-Saale.
Instituto Geologico de Mexico.
Royal University Library, Upsala.
Royal University of Norway, Christiania.
Royal University of Denmark, Copenhagen.
L'Académie Royale Suédoise des Sciences, Stockholm.
Societé Impériale Mineralogique de St. Petersbourg.
Academy of Sciences, Chicago.
Academy of Sciences, St. Louis, Mo.
Academy of Natural Sciences, Philadelphia, U.S.A.
American Philosophical Society, Philadelphia, U.S.A.
American Museum of Natural History, New York.
Boston Society of Natural History, U.S.A.
Elisha Mitchell Scientific Society, North Carolina.
New York State Library, Albany.
Rochester Academy of Science, New York.
Smithsonian Institution, Washington.
United States Geological Survey, Washington.
United States National Museum, Washington.
Museum of Comparative Zoology at Haward College.
Royal Society of New South Wales, Sydney.
Department of Mines, Sydney, N.S.W.
Australian Museum, Sydney, N.S.W.
Australian Institute of Mining Engineers, Melbourne.
Novia Scotian Institute of Science, Halifax.

W. Lower Carter.

Statement of Receipts and Expenditure of the Yorkshire Geological and Polytechnic Society, from 3rd October, 1896, to 8th October, 1897.

REVENUE ACCOUNT.

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
To Balance in Treasurer's hands, 3rd October, 1896	12	15	1	By Maull & Fox	3	0	0
„ Transfer from Capital Account ...	12	0	4	„ Mintern Bros....	6	2	6
„ Subscriptions	65	13	0	„ Geo. West & Sons	2	14	10
„ Sale of Proceedings	7	19	6	„ Francis Carter	5	2	6
„ Halifax Corporation Interest ...	10	3	0	„ Morgan & Kidd	12	0	0
				„ A. Brothers & Co.	1	6	9
				„ James Green	11	0	0
				„ Postages and Petty Cash	11	15	7
				„ Expenses of Meetings	13	7	0
				„ Whitley & Booth	40	17	8
				„ Balance in Treasurer's hands... ...	1	4	1
	£108	10	11		£108	10	11

CAPITAL ACCOUNT.

To Balance in Treasurer's hands, 3rd October, 1896	0	14	4	By Transfer to Revenue Account ...	12	0	4
„ Subscriptions	11	6	0				
	£12	0	4		£12	0	4
To Halifax Corporation Bond ...	£350	0	0	Audited 22nd January, 1898. GEO. PATCHETT.			

RECORDS OF MEETINGS.

Council Meeting, Philosophical Hall, Leeds, 1st April, 1897.

Chairman :—Mr. Richard Reynolds, F.C.S.

Present :—Messrs. P. F. Kendall, W. Cash, J. E. Bedford, J. Stubbins, H. Crowther, C. W. Fennell, J. J. Wilkinson, and W. L. Carter (Hon. Sec.).

The minutes of the previous Council Meeting were read and confirmed.

Letters of regret for non-attendance were received from Messrs. A. Lupton, J. W. Stather, and J. R. Eddy.

The following accounts were passed for payment :—

	£	s.	d.
Mintern Bros. for Plates	6	2	6
Morgan and Kidd for Plates	12	0	0
G. West and Sons for Plates	2	14	10
Maull and Fox for Plates	3	0	0
F. Carter—Circulars and Stationery ...	5	2	6
	£28	19	10

The Excursion Programme was then considered. After some discussion Pateley Bridge was selected as the place for the Spring General Meeting and Field Excursion. The draft programme included visits to Brimham Rocks, Pateley Compensation Reservoir, Goydon Pot, and How Stean Beck.

Election of Governor of the Yorkshire College. According to resolution of the Council, passed on Sept. 8th, 1896, ballot papers were given out, and Mr. P. F. Kendall, F.G.S., appointed Scrutineer. The Rev. W. Lower Carter, M.A., F.G.S., was elected.

British Association Delegate. As no member of the Council present proposed attending the Toronto Meeting of the British Association, Mr. G. W. Lamplugh, F.G.S., was appointed the delegate on the Corresponding Societies' Committee.

Sanitary Science Congress. A letter was read from the Sanitary Institute asking for the appointment of two delegates to the Leeds Meeting in September. Messrs. J. E. Bedford, F.G.S., and W. L. Carter, M.A., F.G.S., were appointed.

A letter was read from Mr. P. F. Kendall, F.G.S., inviting the members of the Society to join the Glacialists' Association in a Field Excursion to Appleby at Easter. The invitation was accepted and the Council Instructed the Hon. Secretary to issue a circular to the members notifying the excursion.

General Meeting and Field Excursion in Nidderdale, May 22nd to 24th, 1897.

Saturday, May 22nd.—The party, led by Mr. John Farrah, F.R.Met.S., visited sections in the Millstone Grit series near Ripley in the morning, and devoted the afternoon to the examination Brimham Rocks.

The General Meeting was held after dinner at the King's Arms Hotel, Pateley Bridge, under the presidency of Edward Yorke, Esq., J.P.

Letters of regret for non-attendance were read from Messrs. W. Gregson and W. Cash.

The following new members were elected:—

Henry Carpenter Marsh, Leeds.
William Hastings Crofts, Hull.
Rev. Chas. T. Pratt, M.A., Cawthorne.
Geo. Fawcett Tindall, Tadcaster.
Thomas Sheppard, Hull.
J. H. Lofthouse, Harrogate.
G. Slater, Carlisle.
Joseph Teal, Yeadon.
R. H. Kitson, Leeds.
J. W. Broughton, Skipton.

An address on "The Mining had other Interesting Features of Nidderdale" was delivered by the Chairman.

An address on "The later Physical History of the River Nidd" was delivered by Mr. Percy F. Kendall, F.G.S.

A note on "The Vallum in relation to the Roman Wall from Newcastle to Carlisle" was communicated by the Rev. E. Maule Cole, M.A., F.G.S.

These papers were followed by a discussion in which Messrs. C. W. Fennell, John Farrah, and W. L. Carter took part, and Mr. Kendall replied.

A Resolution of sympathy with Mrs. Tate, on the sudden death of Mr. Thomas Tate, F.G.S., (April 27th) a member of the Council of our Society, was moved by Mr. P. F. Kendall, F.G.S., seconded by Mr. C. W. Fennell, F.G.S., and carried. References were made to Mr. Tate's wide scientific knowledge and accurate work, and especially to his important work as Secretary of the Yorkshire Boulder Committee.

A hearty vote of thanks was accorded to the Chairman, for his kindness in presiding.

Monday, May 24th.—The party proceeded by wagonettes to Lofthouse. A stop was made to allow of the inspection of the works for the Compensation Reservoir which was being constructed by the Bradford Corporation along the line of the old moraine, and to see Gouthwaite Hall. Subsequently the water-gushes at Lofthouse, Goydon Pot, Manchester Hole, and How Stean Beck were visited, and the party returned to Pateley Bridge for tea.

General Meeting and Field Excursion at Scarborough, July 8th, 9th, and 10th, 1897.

Thursday, July 8th.—The Members were joined by the Geological Section of the Yorkshire Naturalists' Union. A wagonette took the party to Suffield Heights, where a quarry in the Coral Rag was examined. The route was continued on foot, by Hackness Hall to Silpho, where another quarry, containing large numbers of *Phasianella*, was worked. Rejoining the conveyance at Hackness, the party drove down Forge Valley to Ayton quarries, where fine specimens of *Thamnastræa* were secured, and thence returned to Scarborough.

Friday, July 9th.—The party, under the leadership of the Rev. E. Maule Cole, M.A., F.G.S., visited the Castle Hill, and examined the exposures of Calcareous Grit, and the works in progress for the new Marine Drive. The 11.15 a.m. train was taken to Gristhorpe. A cross-country walk brought the party to Gristhorpe Cliffs, several heaps of boulders being examined by the way. The cliffs were descended, and the sections between Gristhorpe and Scarborough carefully examined.

The General Meeting was held after dinner, at the Pavilion Hotel, Scarborough, under the presidency of the Rev. E. Maule Cole, M.A., F.G.S.

The minutes of the previous General Meeting were read and confirmed.

The Secretary reported a valuable gift from the library of the late Professor A. H. Green, F.R.S., F.G.S., Mrs. Green having very generously presented, through Mr. William Whitaker, F.R.S., a number of six-inch maps of the Geological Survey of the Yorkshire Coal Fields, for the library of the Society. Warm appreciation of this kind gift was expressed by the Chairman, and on the proposition of the Hon. Secretary, seconded by Mr. F. F. Walton, F.G.S., the best thanks of the Society were accorded to Mrs. Green for her useful and valuable gift.

An address on "The Geology of Scarborough and District" was delivered by the Chairman, and followed by a free discussion. A hearty vote of thanks to the Chairman concluded the proceedings.

Saturday, July 10th.—The party, under the leadership of Mr. J. W. Stather, F.G.S., and Mr. Geo. Lether, continued the investigation of the Castle Hill sections. The 12.10 p.m. train was then taken to Cloughton and an examination of the coast section between Hundale Point and Hayburn Wyke was made. The members returned by train to Scarborough.

Council Meeting, Philosophical Hall, Leeds, September 9th, 1897.

Chairman:—Mr. J. J. Wilkinson.

Present :—Messrs. W. Cash, H. Crowther, P. F. Kendall, J. H. Howarth, and W. L. Carter (Hon. Sec.).

Letters of regret for non-attendance were read from Messrs. J. E. Bedford, A. Lupton, T. W. H. Mitchell, J. Hawell, W. Simpson, J. R. Eddy, and D. Forsyth.

The minutes of the previous Council Meeting were read and confirmed.

The following accounts were passed for payment :—

	£	s.	d.
Morgan & Kidd—Plates	2	13	6
F. Carter—Plates, Circulars & Stationery	11	14	4
Whitley & Booth—Separate Copies of Proceedings, 1896 and 1897	12	1	4
Whitley & Booth—Proceedings, 1897	35	17	0
	£62	6	2

The Proceedings.—The Treasurer presented a report on the financial state of the Society, and the Hon. Secretary gave an estimate of the expenditure likely to be incurred by the publication of Vol. XIII., part III. It was resolved that a series of photographs illustrating the Middle Oolites of Filey Bay and Brigg be published, and that Mr. Godfrey Bingley's kind offer of the use of his negatives be gratefully accepted. The Secretary was instructed to obtain estimates from three Leeds firms for the printing of the Proceedings, and to report to the next Council meeting.

Annual Meeting.—A letter was read from the Marquis of Ripon, K.G., approving of the Annual Meeting being held at Ripon, and inviting the members to afternoon tea at Fountains' Abbey. The kind invitation of the President of our Society was unanimously and very heartily accepted.

A draft programme of arrangements was considered and adopted.

It was decided that an "In Memorian" notice of the late Mr. Thos. Tate, F.G.S., with portrait, should be issued with the next part of the Proceedings.

The Hon. Secretary submitted a draft of the Report to be presented to the Annual Meeting, which was approved.

Officers and Members of Council. — The Hon. Secretary reported a vacancy in the Council by the death of Mr. Thos. Tate, F.G.S. The Secretary also read letters from Mr. J. R. Eddy, F.G.S., and Mr. D. Forsyth, D.Sc., M.A., intimating their inability to attend the meetings of the Council, and asking that their names should not be submitted to the Annual Meeting. After some discussion it was resolved that the Council much regretted that feeble health should necessitate the retirement of their old and valued colleague, Mr. Eddy, and that the pressure of professional duties should prevent Dr. Forsyth from allowing his name to be retained on the Council. It was resolved that the names of Messrs. Godfrey Bingley, F. W. Branson, F.I.C., and F. F. Walton, F.G.S., should be nominated at the Annual Meeting to fill the three vacancies in the Council.

It was also resolved, after some conversation on the advisability of curtailing the time spent on routine work at the Annual Meeting, that the Secretary should prepare a nomination paper with the names of the Officers and Council as amended above, and print and circulate it amongst the members as the nomination of the retiring Council. But that any member have the right to nominate other names, and that, in case of such extra nomination, a ballot be taken at the Annual Meeting.

The General Meetings and Field Excursions for 1898 were then considered. It was resolved that the 1898 Meetings be held at Clapham, with Professor T. McKenny Hughes, F.R.S., as leader, and at Malton, for the Wolds, with Rev. E. Maule Cole, M.A., F.G.S., as leader.

Annual General Meeting at Ripon, Thursday, October 7th, 1897.

By the kind invitation of the President of the Society (The Marquis of Ripon, K.G.), the members paid a visit to Studley Royal and Fountains' Abbey. The party went to the Canal Gates in wagonettes, and were met by Mr. T. S. Mason, of

Fountains' Hall, who conducted them round the ornamental gardens. The Marquis of Ripon met the members at the Abbey, and showed them over the ruins, pointing out many interesting features, and detailing the work that had to be done in order to keep the fabric from falling further into ruins. His Lordship then entertained the members and their friends to tea in the calefactory.

The Annual Meeting was held at the Town Hall, Ripon, in the Large Room, kindly placed at the disposal of the Society by the Mayor and Corporation. The President, The Marquis of Ripon, K.G., occupied the chair.

The minutes of the previous General Meeting were read and confirmed.

Letters of regret for non-attendance were read from The Mayor of Ripon (Mr. Tom Williamson), The Bishop of Ripon, Messrs. W. Simpson, F. F. Walton, A. R. Dwerryhouse, R. Akeroyd, J. Bedford, J. T. Atkinson, H. S. Childe, J. Hawell, G. Slater, A. H. Pawson, W. C. Slingsby, G. H. Parke, F. W. Branson, W. Cash, E. Martin, J. F. Ianson, W. E. Garforth, and C. W. Fennell.

The Hon. Secretary read the Annual Report, and, in the absence of the Treasurer, presented the Financial Statement, both of which were adopted.

The following new members were elected:—

Albert Jowett, B.Sc., Bradford.
J. Mitchell Wilson, M.D., Doncaster.
Edwin Martin, Filey.
Adam Millward, Harrogate.
Abraham Lambert, Harrogate.

The Officers and Council for 1898 were then elected:—

President:
The Marquis of Ripon, K.G.

Vice-Presidents:
Earl Fitzwilliam, K.G.
Earl of Wharncliffe.
Earl of Crewe.

Viscount Halifax.
H. Clifton Sorby, LL.D., F.R.S.
Walter Morrison, M.P.
W. T. W. S. Stanhope, J.P.
James Booth, J.P., F.G.S.
F. H. Bowman, D.Sc., F.R.S.E.
Richard Reynolds, F.C.S.
W. H. Hudleston, F.R.S.
J. Ray Eddy, F.G.S.
David Forsyth, D.Sc., M.A.

Treasurer:

William Cash, F.G.S.

Hon. Secretary:

William Lower Carter, M.A., F.G.S.

Auditor:

George Patchett, Junior.

Council:

J. F. Atkinson, F.G.S.
J. E. Bedford, F.G.S.
Godfrey Bingley.
F. W. Branson, F.C.S.
J. H. Howarth, F.G.S.
P. F. Kendall, F.G.S.
Prof. A. Lupton, F.G.S.
G. H. Parke, F.L.S., F.G.S.
R. Reynolds, F.C.S.
W. Rowley, F.G.S.
J. Stubbins, F.G.S.
F. F. Walton, F.G.S.

Local Secretaries:

Barnsley—T. W. H. Mitchell.
Bradford—J. E. Wilson.
Driffield—Rev. E. Maule Cole, M.A., F.G.S.
Halifax—W. Simpson, F.G.S.
Harrogate—R. Peach.
Hull—J. W. Stather, F.G.S.
Leeds—H. Crowther, F.R.M.S.
Middlesbrough—Rev. J. Hawell, M.A., F.G.S.
Skipton—J. J. Wilkinson.
Thirsk—W. Gregson, F.G.S.
Wakefield—C. W. Fennell, F.G.S.
Wensleydale—W. Horne, F.G.S.

The Most Hon. the President then delivered an Address.

The following papers were read :—

"The Danes' Graves: Part I. Historical Summary." By Mr. J. R. Mortimer.

"Notes on Danes' Graves near Driffield." By Rev. E. Maule Cole, M.A., F.G.S.

"On the Identification of Localities in Norway from which boulders in Yorkshire Drift Deposits may have been derived." By Mr. Percy F. Kendall, F.G.S.

"Some Yorkshire Caves." By Mr. S. W. Cuttriss.

"The Halifax Coal Strata." By Mr. James Spencer.

"On the Fossil Fishes of the Upper Lias of Whitby : Part III." By Mr. Arthur Smith Woodward, F.L.S., F.G.S.

"The Composition of the Spar occurring in Mother Shipton's Cave, Knaresborough." By Mr. B. A. Burrell, F.I.C.

A vote of thanks was unanimously passed to the President for presiding over the Meeting, and for his kind and generous entertainment of the Society.

A vote of thanks was also passed to the Mayor and Corporation of Ripon, for kindly lending the Large Room at the Town Hall for the Meeting.

The Members dined together at the Unicorn Hotel, Ripon, under the presidency of the Most Hon. the Marquis of Ripon, K.G.

After dinner a selection of new lantern slides was exhibited, and, by the kind permission of the Town Clerk, the members had the opportunity of examining the ancient municipal regalia.

In connection with the Annual General Meeting, a Field Excursion was arranged, on Friday, October 8th, to Hackfall and the Gorge of the Ure between Masham and West Tanfield. The party, led by Mr. T. S. Mason, went to Masham by train. Some time was spent in the ancient Church, and then the Gorge of the Ure was traversed to Hackfall, and thence to Mickley and West Tanfield. Here a short time was given to the Church and Marmion's Tower, and the train was taken back to Ripon where the members separated.

PROCEEDINGS

OF THE

YORKSHIRE GEOLOGICAL AND POLYTECHNIC SOCIETY.

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and WILLIAM CASH, F.G.S.

1898.

THE YOREDALE AND MILLSTONE GRIT ROCKS OF THE UPPER CALDER VALLEY AND THEIR FOSSILS.

BY JAMES SPENCER.

(*Read June 10th*, 1898.)*

Plate LIX.

The Millstone Grits occupy the extensive range of hills, moorlands, and dales forming the head waters of the river Calder, from the anticlinal down to Halifax and Elland. The great mountain wall of Kinder Grit, which ranges from Blackstone Edge on the south to Black Hambledon on the north, with an average height above the level of the sea of nearly 1,500 feet, is broken through at Todmorden by a valley about two miles in width. Here the river Calder from the Burnley valley is joined by the

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[*It was the intention of the late Mr. Spencer to have carefully revised all the details of this paper prior to publication, but this intention was frustrated by his sudden death.—Ed.]

stream from Dean Head on the south, and the combined streams then flow in an easterly direction, by Hebden and Sowerby Bridges, to Elland. The valley of the Calder divides the whole area into two halves, and, being the lowest part, it drains the whole district, receiving from the north its tributary streams, the Calder at Mytholm, the Hebden and its affluent from Horse Bridge Clough at Hebden Bridge, the stream from Luddenden valley at Luddendenfoot, and the Hebble from Halifax, while the streams from St. John's Valley, the Ryburn, and the Blackwater join it from the south.

The Millstone Grit rocks form three natural groups, named after the three principal rocks, viz., (I.) Kinder Grits, (II.) the Third Grits, and (III.) the Rough Rock.

I. and III. have the greatest range and most uniform thickness, while the Third or middle grits are the most variable, both in thickness and range. In fact, according to the Geological Surveyors, the Third Grits form a series of lenticular beds in the great mass of Shales which divide the Kinder Grit from the Rough Rock.*

The Kinder Grit forms the subsoil of the high and extensive moorlands forming the boundary between the counties of Yorkshire and Lancashire, and reaches the height of 1,550 feet on Blackstone Edge and on Black Hambledon. It has suffered denudation on a vast scale, areas of many miles square having been swept away, and the underlying Yoredale rocks exposed.

Before proceeding further with the description of the Kinder, it will perhaps be advisable to include a brief sketch of these Yoredale beds. In the north, at Widdop, is an oval basin about 1½ miles long by a mile broad, where the Yoredale shales are exposed. This basin is surrounded by bold perpendicular escarpments of Kinder Grit a hundred feet or more in height, and is composed of the grandest masses of conglomerate we have in the district.

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* Memoirs, Geo. Survey, Burnley Coal Field.

On the weathered faces of the great thick blocks of Kinder the pebbles stand out in great relief and form three-quarters of the rock; the pebbles, some round, some oblong, are formed of various minerals, quartz, orthoclase, felspar, garnets, tourmaline, together with many macroscopic fragments of rock-forming minerals.

The Yoredale shales occupy the bottom of the valley, and in the centre the large reservoir belonging to the Halifax Corporation is situated. About half a mile south of Widdop basin is Gorple water, a smaller basin (about half a mile in diameter), which has also been scooped out of the Kinder Grit, exposing the Yoredale shales. This place is very interesting to geologists on account of the splendid sections exposed, showing the bending of the anticlinal axis. The Kinder rock, here more than 100 yards in thickness, has been bent into a broad arch, the western side abutting against the great anticlinal fault, which may be well seen at Hare Stones, on the western edge of the basin; while on the eastern side the Kinder rock gradually flattens out and soon becomes covered up by the shales of the lower Third Grits. The whole of this great mass of Kinder, forming Black Hambledon ridge, has been thus bent over from west to east, from Gorple to Hawkstones, a distance of from two to three miles, without breaking. It is now more than thirty years since the writer first beheld this truly wonderful phenomenon, but many a long tramp has he had over the wild moorlands since that time.

The Kinder Grit and Yoredale strata of Blackstone Edge also bend over, and the latter abuts against the anticlinal fault, as shown in Section I.

The great anticlinal fault has a down-throw to the west of at least 1,000 feet, for the upper Third Grits are thrown down in many places against the Kinder Grit. [Geology of the Burnley Coal Field.] The Yoredale rocks are exposed in the Todmorden valley for a space of about 2½ miles square, and more than 1,000 feet of Kinder rock and Yoredale strata have been carried away from the centre of the valley, thus exposing a great thickness of Yoredale rocks. The valley of the Calder from this place down to Hebden Bridge Railway Station and the deep dales of the Hebden and Horse Bridge Clough have also been excavated out of the same rocks.

In the Withins valley, divided from that of Todmorden by a narrow ridge of Kinder, the Yoredale shales are also exposed.

The Yoredale shales of the Hebden and Horse Bridge Clough valleys have long been famous for the rich suites of beautiful fossils which they have yielded to fossil collectors.

One or two layers of disconnected blocks of impure limestone of varying sizes occur in the shales of these valleys; the upper portions of many of them contain abundance of marine remains such as Goniatites, Nautilus, Orthoceras, Aviculopecten, Posidonomya, Buccinum, fish-remains, &c. Occasionally drifted fragments of Dadoxylon and other vegetable remains are found in them. In each of these valleys there are also several outcrops of beds of shale, containing crushed Goniatites, Aviculopecten, and other marine fossils. There is at least one bed containing the remains of a small species of encrinites, of which not only fragments of the stems but also nearly complete specimens with heads have been found. In the limestone blocks such undoubted Mountain Limestone fossils as Productus, Spirifera, Belerophon, Pleurotomaria, Pecten, Natica, Modiola, Goniatites, Nautilus, Orthoceras, encrinites, &c., &c., occur.

The Yoredale shales, taken as a whole, are of marine origin, as shown by their marine remains, but here and there we have indications of ancient land surfaces, such as coal beds, seat earths, and galliard rocks full of stigmarian roots and plant-remains.

Upon one of my visits to Horse Bridge Clough a number of men were busy at work digging out foundations for a weir, and had exposed a face of about three yards in depth and five or six yards across the bed of the stream. When I turned to examine the material brought out I found, to my surprise, that it was literally full of plant remains in a great variety of species.

There were specimens of Lepidodendron, Sigillaria, Stigmaria, Calamites, Dadoxylon, Artisia, and ferns in abundance, the whole bed seemingly being full of them; not even in the Coal Measures do I recollect ever seeing a more interesting or a more prolific bed of plant remains. In going up the bed of this brook and many others in our district, the geological student becomes acquainted with many interesting phenomena not noticed in popular text-books on geology. The shales are frequently seen to be bent and twisted for short distances, and enclosed by under- and over-lying beds of sandstone, which are not affected in the same way. But there are also other larger anticlinal and synclinal axes here and there in the shales, which do affect the overlying strata. Several of these may be seen along the sides of this watercourse. Near here also may be seen the termination of one of those lenticular beds of sandstone so common in these and also in the Third Grits.

Two hundred yards or so further up the stream from the weir, at a place called Wet Ing, the Kinder Grit has been thrown into the valley in a great triangular mass by the combined effects of two faults. One of these runs diagonally across the valley and throws the beds of sandstone down at steep angles. A short distance further up stream a bed of Yoredale limestone crops out on the western side of the stream which has yielded a great number and variety of Yoredale fossils. If you get a piece of the rock and break it in pieces with your hammer you will get few fossils out whole as they break before the rock will break, but old Samuel Gibson, the original discoverer of these fossils, found out a better way of extracting them out of their stony matrix. Being a blacksmith by trade, he took some of the material home and roasted it to a dull red heat and then plunged it into the water-trough; when cool he took it out and gently tapped it with the hammer when the shells rolled out, a large proportion being perfect. I am not aware whether Mr. Gibson ever published any account of his most ingenious device, but several others have made claims to it long since his day. I had been in the habit of extracting these beautiful fossils in this way for some years when I first came across a newspaper paragraph in which the discovery of the process was claimed by a popular writer on geology of that day.

A short distance further up the valley and we come to the beautiful little waterfall of Lumb Bridge, which only lacks notoriety to be much more appreciated than it is. Here a useful lesson in the process of valley formation may be learnt. The waterfall is at the head of a narrow channel worn out of the Kinder Grit, and the water falls over a ledge of grit having under it some four or five yards of shale which is continually being worn away by the action of the spray, so that from time to time the ledge of grit breaks away and thus the fall recedes. Frost, snow, ice, floods, and other denuding agents carry on the work of valley formation still further by digging away the sides of the ravine and carrying away the material.

The Kinder forms the floor upon which the Third Grits were laid down. It is of great thickness along and near the anticlinal, and is often split by beds of shale into two or three beds, but seems to get thinner eastwards. This floor of Kinder forms an inclined plane from the altitude of 1,550 feet at Blackstone Edge and Black Hambledon down to 350 feet in the Luddenden and Ryburn valleys.

The Third Grits were originally laid down upon the Kinder floor in pretty even beds of sand and mud, and afterwards hardened into sandstone and shale, and, upon the upheaval of the Pennine Hills, were, along with the Kinder and other rocks, bent and fractured in various directions. Since that time they have been carved into hills, moorlands, and valleys by the endless process of denudation, so that the Kinder rock has been exposed over a large area of the Pennine Chain and also in the valley of the Calder and its tributaries as far east as the valleys of the Ryburn and Luddenden.

During the making of the branch line from Sowerby Bridge to Ripponden a good opportunity was afforded to local geologists for examining the rocks of the Ryburn valley as far as Ripponden. The tunnel from Sowerby Bridge Station into the Ryburn valley was excavated in the shales just under bed D of the Third Grits, the crown of the tunnel being carried through the bottom bed of the series. From the west end of the tunnel the line runs in the same bed of shale as far as Mill House, where a lower bed of grit—the top bed of Kinder—makes its appearance in the cutting. A short distance further up the line a fault crosses it, which throws down the Kinder so that the top beds of the rock abut against the lowest bed. In these upper beds—composed of shale, rag, and stone—is the usual thin seam of coal, here about six inches in thickness. About half-a-mile further up, at Rough Hirst, a cutting shows the coal running along on the east side of the line for some distance, nearly on a level with the rails. At Little Haven, another fault crosses the line diagonally in a north and south direction, which throws the rock up to the east about 50 feet. Near Ripponden, a fault throws the rock down out of sight, but it soon begins to rise again and occupies the bed and sides of the brook, up as far as the bottom of Butts Clough, where it is thrown up to the south by another fault. At Slitheroe Bridge the top beds of the Kinder, with the usual bed of coal, are exposed. The Kinder Grit occupies a large area in Booth Dean, where it rises with the slope of the ground up to the top of Blackstone Edge.

THIRD GRIT ROCKS.

The Third Grits occupy an extensive area on each side of the river Calder. "These middle grits" were divided by the Geological Surveyors into four divisions, and named A, B, C, and D, D being the lowest and A the highest bed.*

In their memoir on the "Geology of the neighbourhood of Dewsbury, Huddersfield, and Halifax" the order of the letters is reversed, A being applied to the lowest of the Third Grits and D to the highest. It is of little consequence which order is adopted so long as the reader knows to which rock each letter is applied. Being accustomed to the use of the first method, that method will be adhered to in this paper. The D grit is a most variable rock both in quality and thickness.

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* Geology of the Burnley Coal Field.

On Erringdon Moor, south of the Calder, it is upwards of 300 feet in thickness "and faces westwards with a splendid escarpment of conglomerate, passing upwards into flagstone." A large bay has been scooped out of this massive* grit rock, in Crag valley, called Broadhead Clough, which is strewn with large blocks of grit, "which is here of so coarse and massive a character as to resemble the typical Kinder Scout Grit."*

This D grit occupies an extensive range along the sides of the Calder valley and its tributaries. It has generally a strong grit on the top, and a thick bed of galliard rock at bottom, with intermediate beds of shale and stone, and two thin seams of coal.

Hathershelf Scout, near Mytholmroyd, is formed of this rock, which is there nearly 200 feet thick, with a bed of shale 20 feet in the middle, and two thin seams of coal. It occurs also in great thickness at Sowerby Bridge Station, and in the cutting to the east, where it gradually sinks below the surface.

A bed of shale, varying in places from 40 to 100 feet in thickness, overlies the D rock, and upon the shale lies the C rock, which is usually a flag rock of varying thickness, and has been worked in various places in the district. This rock is also overlaid by a bed of shale of about 80 to 100 feet in thickness.

We next come to the B grit, which is a very important rock in some places, but, like the C rock, it is liable to thin away in places and then come in again. On Wadsworth and Midgley Moors, and also at Deep Clough and other places in the Luddenden valley, it has been worked for flags and building stone.

This B rock is at Deep Clough, opposite Castle Carr, about 60 feet thick, and is overlaid with a rough grit rock. It yields good building stones and flags. It is interesting to the geologist on account of the large number of fossil plants which occur in it, such as *Lepidodendron obovatum*, *L. aculeatum*, Sternbergia (Artisia), *Sigillaria tessellata*, *Halonia regularis*, ferns, Cauleopteris, *Stigmaria ficoides*, numerous fruitstones, Calamites, &c.

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* Burnley Coal Field, p. 117.

All the sandstone beds contain fossil plants in places, and many of the shales also yield them, but those which occur at or near the surface of the shales are seldom well enough preserved for specific distinction.

The A grit has a greater surface range than any of the other Third Grits. It forms the surface rock of Warley and Saltonstall Moors, and thence runs round the head of Luddenden valley to the upper end of Wadsworth Moor; also that of Crow Hill on Sowerby Moor and other places. This grit, like all the other Third Grits, is liable to thin away and deteriorate into rag and shale. It is a typical grit on Warley Moor, but in Wheatley valley, a mile and a half to the south east, it has become a mass of bedded rag and shale. This rock crops out in Brimsroyd Clough, Norland, where the upper part consists of raggy stone in beds of from 1 to 2 feet thick, and the lower part of a mass of thin slaty layers, each from $\frac{3}{4}$ inch to 2 inches thick. The D rock furnishes us with another example of this character, for from 200 feet at Hathershelf Scout it dwindles down to 50 or 60 feet at Higham, in Sowerby, in a distance of about a mile and a quarter. The Third Grits spread over a large area of the moorlands on each side of the Calder, and reach the height of 1,350 feet on Warley and Wadsworth Moors, 1,150 feet on Crow Hill, Sowerby, and 1,369 feet on Manshead.

Rough Rock.

The Rough Rock is a massive grit of from 100 to 150 feet in thickness. This estimate includes the shales and flagstones underlying it, which in this district form part of it. It ranges from Nab Hill, 1,470 feet above sea level on Oxenhope Moor, down by Hunter Hill to Halifax, where it sinks under the Lower Coal Measures, and to Elland where it is covered by the alluvium of the valley. It also forms the surface of Norland and Greetland Moors.

It is generally a thick, rough, false-bedded grit of from 70 to 100 feet in thickness, with flagstone and building stones at the base.

The Flagstone group varies in thickness from 12 to 60 feet, and is divided from the Rough Rock by a bed of shale of from 8 to 20 feet in thickness, but at Halifax this shale is generally absent.

In Derbyshire the Flagstone is divided from the Rough Rock by a much thicker bed of shale and is termed by the Geological Surveyors their 2nd Grit rock. But the writer has shown in a former memoir* that the Flagstone in our neighbourhood is really part of the Rough Rock which gave off Flagstone beds at intervals as it was laid down.

The Rough Rock in many places yields good building stones and forms most excellent materials for curbs and setts for our streets, while the underlying Flagrock yields some of our best flags and building stones.

In some places, in the middle of the Flagrock, the flags have been laid down at a different angle to the beds above and below. A case of this sort occurs in the Moor End Quarries, and other cases of a similar character are not infrequent. One of the best examples we have seen was taken from a railway cutting on the branch line from North Dean to Stainland. A white grit of from 20 to 30 feet in thickness was exposed in the cutting; in the midst of the rock a series of flags and thin shales were laid down at an angle of about 22½ degrees. The beds extended all through the cutting, a distance of about 200 or 300 yards.

DESCRIPTION OF THE STRATA ALONG THE LINE OF SECTION I.

Section I. proceeds from the Halifax coal strata of Ringby Hill, two miles north of Halifax Town Hall, across the Rough Rock of Ovenden to Camp End (Warley Edge), thence through the Third Grits down to the Calder near Cooper Mill, half a mile east of Luddendenfoot. Here it cuts through the Kinder Grit which has been brought to the surface by a fault. The section then runs up to Crow Hill in Sowerby and forwards through the moorlands of Manshead; then crossing the Ryburn, where the Kinder Grit comes to the surface, it proceeds up the eastern side of Black Castle water to Blackstone Edge (1,550 feet above sea level), thence over the Yoredale outcrop and the anticlinal fault and the Third Grits to the outcrop of the Lancashire coal strata, about two miles east of Littleborough. The length of country covered by the section is about 11 miles, in a north-east and south-west direction. The dip of the strata is also in a north-easterly direction. From the anticlinal axis down to the river Calder the average dip between the two places is about 200 feet per mile, or one yard of fall for every 26 yards. From the Calder to Ringby Hill, north of Halifax, in the line of the section, the dip is 160 feet per mile, or one yard in every 33 yards. The dip of the strata in Shibdendale is also to the north-east.

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* Trans. Manchester Geological Society.

The dip or inclination of the strata is very interesting to the geologist, and must be taken into account in all our calculations concerning the thickness of the various strata, &c. It is also very important that measurements of these dips should be taken not merely in one direction but in several, and not only for a limited distance but for many miles in length, before our deductions from them can be relied upon. A section of the strata taken from Black Hambledon to the Fly quarries (Oxenhope), a distance of eight miles (direct west and east), gives us a fall of one yard in 41, and from Oxenhope Moor, *viâ* Halifax, to Elland the Rough Rock falls from 1,450 feet in the former place to about 250 feet in the latter, which gives a fall of 1,200 feet, or 150 feet per mile, or one yard in 39. From these calculations it will be seen that the old notion of a dip of one yard in 20 is not correct when the dip is taken over several miles in extent, although in a few places it may be applicable; in fact, dips to any amount from vertical 70°, 45°, 40°, 22½°, 15°, 12°, 5°, down to a dead level, occur locally in connection with faults. It will be seen from Section I. that the hilly country through which that section runs, and also that to the north-west of it, really form part of the Pennine Chain, because their strata are all affected by that great upheaval. It is only when we get a little further away from the Pennine Chain that the dip assumes a general north-west and south-east direction.

THE CHARACTER AND THICKNESS OF THE STRATA SHOWN IN SECTION I.

The Rough Rock and flagstone and intermediate shales under Ovenden and Halifax, Norland and Greetland Moors have a thickness of about 150 feet, and the shales below are about 150 to 200 feet. In these shales is a bed of marine fossil shells containing Aviculopecten, Posidonomya, and Goniatites, these being the most common fossils in all the Millstone Grit shales, besides many other shells and fish remains. This fossiliferous bed has been exposed in several places in the district, and has yielded to the writer between 20 and 30 species. Towards the base of the shales is a bed of coal about six inches in thickness, having under it a bed of seat-earth.

On the summit of Crow Hill in Sowerby is an outlier of these shales, crowned by about 12 feet of flagstone.

The Third Grits may be regarded as intermediate beds or "middle grits," which occur in the great mass of shales between the Rough Rock and the Kinder Grits. The beds A and D are fairly persistent over a large part of our district, but the bed A, which is a typical grit under Cold Edge, becomes deteriorated in Wheatley valley and other places into raggy shale. The beds B and C are of a lenticular character, and seem to thin away into rag and shale now and then and come in again, but often at different horizons, in the shale, rendering it a difficult task to correlate them in different localities. The total thickness of the Third Grits in Calderdale in the line of the section is about 600 to 700 feet, but further west the lower beds seem to increase in thickness.

The average thickness of the Third Grits of the Section.

A	40 feet,	shales	100 feet	= 140 feet.
B	60 ,,	,,	100 ,,	= 160 ,,
C	50 ,,	,,	100 ,,	= 150 ,,
D	80 ,,	,,	150 ,,	= 230 ,,
				680 ,,

In connection with each of these grits is a thin seam of coal and underlying seat-earth; only in one place have we found the seat-earth wanting, but in several instances the seat-earth occurs without the coal, indicating that the coal had been denuded away before the seat-earth was covered up.

From what we have said about the lenticular character of the beds of grit and sandstone, it will be understood that in drawing the beds as continuous across the section, and on the same horizon, we have only indicated their general average position. In places some of the beds of grit and sandstone cannot be seen, having either thinned away or are too thickly covered with clay or other *débris*, but as a rule they furnish us with fairly good escarpments.

We have endeavoured in the above estimates to give a correct idea of the thickness of each bed of grit and shale from data obtained from beds exposed either along the line of the section or in its vicinity, and in comparing them with their heights above sea level (taken from the Ord. Survey) we know that our estimates are tolerably correct.

Description of Section II.

SECTION OF THE MILLSTONE GRIT ROCKS FROM WEST TO EAST ALONG THE SOUTH SIDE OF THE RIVER CALDER.

No continuous section of the beds along the lower levels of the Calder valley has hitherto been attempted. The numerous breaks in the sides of the valley, through which its tributary streams join the river, render it a difficult task to make a continuous geological section along the banks of the river. At length, after much study and research, I have made the attempt, and trust that the section will be found to be fairly accurate.

The section is taken along the south bank of the river and as near to it as is compatible with obtaining a continuous section.

The inclination of the strata from Hebden Bridge to Sowerby Bridge seems to be only very slight, but from Norland down to the Calder at West Vale it is more rapid.

The wide vale of Todmorden has been scooped out of Yoredale strata, and a great thickness of shales and grits is exposed. At Eastwood a fault crosses the valley, and throws these strata below the level of the valley to the east, but they soon rise to the surface again and form the sides of the valley down to below Hebden Bridge Station. The Kinder Grit crowns the edges of the Calder valley from Eastwood down to Wood End, half-a-mile below Hebden Bridge Station, where it is thrown down to the east under the alluvium of the valley by the Wadsworth fault. Just east of the fault the section passes through the "Mytholmroyd moraine," and the sides of the valley are formed of Third Grits down to near Luddendenfoot Station. At this point the Kinder Grit is again brought to the surface by the Midgley fault, and may be seen forming the sides of the cutting below the station. The beds dip rapidly down to Cooper Mill where they form a synclinal axis due to an abrupt bend in the grit rocks, which have been thrust up in the form of a pyramid to a considerable height above the level of the river. The upper Kinder shales have a dip of 10° on each side of this pyramid. There is a thin bed of coal in these shales, which along with the shales has been bent into a sharp angle. On the east side of the bend the shales and Kinder have been thrown down by a fault to the level of the valley, leaving three or four yards of shales adjoining the grit pyramid.

This is the most easterly exposure of the Kinder Grit in Calderdale, and is a most interesting section.

The Kinder gradually sinks below the surface and the overlying shales form the valley bottom down to Sowerby Bridge, where the bed D of the Third Grits may be seen on the south side of the station and in the cutting east of it. This rock has two thin coals and a thick bed of galliard rock associated with it, by means of which it can be traced from above Pecket Well down the left side of the valley to this place, a distance of five or six miles.

From Sowerby Bridge down to North Dean the Third Grits, which appear to decrease in thickness as they go eastwards, gradually sink below the surface, and finally the Rough Rock, the uppermost member of the Millstone Grit rocks, sinks under the Lower Coal Measures at Halifax and Elland.

Sections I. and II. will show that in this district there is no break or natural dividing line between the Yoredale strata and the Millstone Grits, nor between the latter and the Lower Coal Measures. This is fully borne out by evidence derived from the study of the fossil shells found in these beds. The whole series of Yoredale, Millstone Grits, and the Halifax Coal strata of our districts appear to be estuarine deposits, but in some places, as in the neighbourhood of Harrogate, Ripon, Fountains Abbey, Teesdale, &c., the corresponding beds are largely of marine origin, and contain a large number of Mountain Limestone forms. We allude to this fact to remind the student that whilst our local beds of sandstone and grit and shales were being deposited in a large estuary, some 40 or 50 miles to the north-east contemporaneous deposits were being formed in the sea, consisting mainly of limestone and calcareous shales and thin grits, and containing a similar suite of marine fossils to those of our Millstone Grit shales, but with a greater proportion of deep-sea forms. During the frequent oscillations of the levels of the land and sea-bed, our Millstone Grit area must have been frequently in communication with the sea, whose inhabitants, migrating into our area, left their remains in the fossiliferous beds of the Millstone Grit shales.

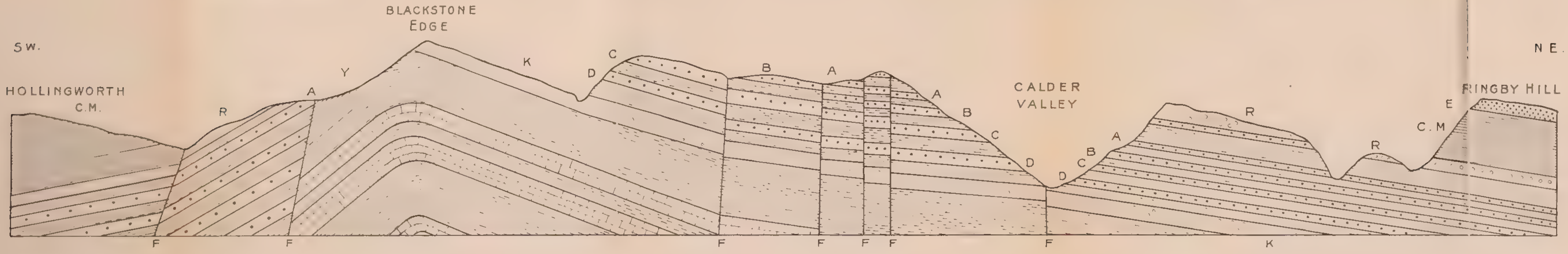
The Millstone Grits are divided from one another by thick beds of shale; each of these contains one or more beds of fossil shells and fish-remains. All the species found in these beds also occur in the Yoredale strata; the chief difference between the two suites seems to be that the species become fewer and fewer in number as we ascend in the series of beds. The number of specimens of shells in some of the beds is as large, if not larger than occurs in the Yoredale beds. In the shales of the Third Grits passed through in sinking the shafts on Wadsworth Moor for the Halifax Waterworks, beds of black fossiliferous shales full of Aviculopecten, Goniatites, &c., 10 feet to 20 feet in thickness, were met with.

The marine shells and fish-remains found in the roof of the Halifax Hard Bed Coal also belong to the same genera as those of the Yoredale shale, with perhaps a few additional forms.

The gradual development of *Goniatites listeri* is well illustrated in these beds. In the Yoredales this shell is of small form, and good specimens are somewhat rare. They generally occur in the shales of the Yoredale, Millstone Grit, and Coal strata in a crushed condition. In the Yoredale shales of Todmorden small limestone nodules occur in which small specimens of this species are found in a good state of preservation ; all the specimens I have seen are of small size, but as we trace their crushed forms through the shales of the Millstone Grit they seem to gradually increase, both in numbers and in size. In the marine bed over the Halifax Hard Bed Coal *Goniatites listeri* occurs in all sizes from that of a pin's head, or even less, to others from four to six inches in diameter, and in vast numbers. Only a few other species of Goniatites occur in the bed, and none of them seem to have undergone any change in form. The beautiful little shells, *G. looneyi* and *G. gilbertsoni* are of the same size as they are in the Yoredale beds and in about the same relative proportion. *Goniatites reticulatus*, the most common form in the Yoredale rocks, appears to have degenerated in its journey through the Millstone Grits. This beautiful fossil assumed several distinct forms from its birth to its adult stage, when it reached a diameter of three or four inches. But it gradually dwindled away both in size and in numbers in its passage through the grit rocks, and seems to have died out at the end of the Third Grits and the overlying shales.

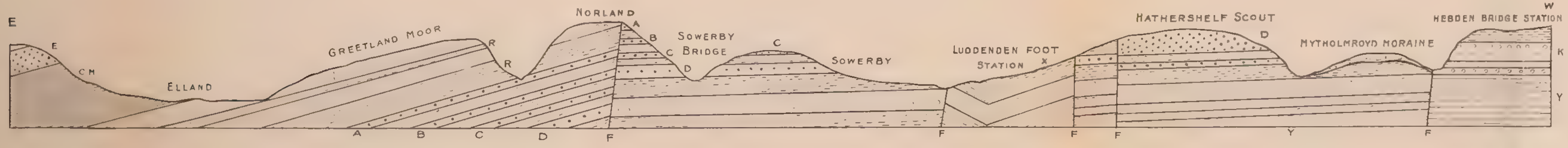
SECTION No 1.

SECTION OF THE STRATA FROM BLACKSTONE EDGE TO RINGBY HILL NEAR HALIFAX



SECTION No 2.

SECTION OF MILLSTONE GRIT ROCKS FROM ELLAND TO HEBDEN BRIDGE SOUTH OF CALDER.



E.	ELLAND FLAGSTONE	LOWER COAL MEASURES.
C. M.	COAL MEASURES	
R.	ROUGH ROCK	MILLSTONE GRIT.
A. B. C. D.	THIRD GRITS	
K.	KINDER GRIT	
Y.	YOREDALE BEDS	
F.	FAULTS	

Horizontal Scale 1½ Inches = 1 Mile

Vertical Scale Inch = 800 Feet.

FOSSILS FROM THE YOREDALE AND MILLSTONE GRIT SHALES.	YOREDALE.	MILLSTONE GRITS.						SHALES under the different grits.
		Kinder.	Third Grits.				Rough Rock.	
	Y	K	D	C	B	A	R	
Goniatites reticulatus Phil.	*	*	*	*	*	*		
,, *striolatus* ,,	*		*	*	*			
,, *obtusus*	*	*	*	*				
,, *gibsoni*	*		*	*				
,, *looneyi*	*	*	*	*				
,, *gilbertsoni*	*		*					
,, *striatus*	*		*					
,, *spirorbis*	*		*	*				
,, *evolutus*	*		*					
,, *calyx*	*		*					
,, *bidorsalis*	*		*					
,, *micronatus*	*							
,, *listeri*	*		*	*	*	*	*	
,, *serpentinus*	*							
Nautilus sulcatus	*		*					
,, *tuberculatus*	*		*					
,, *cyclostomus*	*		*					
,, *subsulcatulus*	*		*					
Orthoceras cinctum	*		*					
,, *steinhaueri*	*							
,, *gesneri*	*							
,, *unguis*	*							
,, *annulare*	*							
,, *attenuatus*	*							
,, *inequiseptum* Phil.	*							
,, *ovale* Phil.	*							
,, *undulatum* Phil.	*							
,, *annulatum* ,,	*							

FOSSILS FROM THE YOREDALE AND MILLSTONE GRIT SHALES.	YOREDALE.	MILLSTONE GRITS.						SHALES under the different grits.
		Kinder.	Third Grits.				Rough Rock.	
	Y	K	D	C	B	A	R	
Melania striata	*							
,, *reticulata*	*		*					
,, sp.	*							
Posidonomya vetustus	*		*	*	*	*	*	
,, *gibsoni*	*							
,, sp.	*		*					
Modiola elongata	*		*	*	*		*	
,, *squamifera*	*		*	*			*	
,, *lingualis*	*							
Aviculopecten papyraceous	*		*	*	*	*	*	
,, *hemisphericus*	*		*	*	*	*	*	
,, *rugosus* Phil.	*		*	*				
,, sp.	*		*	*				
Productus antiquus	*							
,, *spinulosa*	*							
,, *semireticulatus*	*							

FOSSILS OF THE YOREDALE AND MILLSTONE GRIT ROCKS. PARISH OF HALIFAX SERIES.	YOREDALE.	MILLSTONE GRIT SHALES.					
		Kinder.	Third Grits.				Rough Rock.
	Y	K	D	C	B	A	R
Orthis	*						
Nucula	*						
Lingula parallela	*		*	*			*
Orbicula nitida	*						
Pleurotomaria	*		*	*			*
Edmondia sulcata	*	*					
Conularia	*		*				
Encrinites, stems, small sp.	*		*				
Fish-remains :—							
Acanthodus			*				
Elonichthys aitkeni, whole fish, scales, &c.	*		*	*	*		*
Cladodus, teeth	*		*				
Elonichthys striolatus, teeth and scales			*				
Ctenocanthus hybodus, tooth			*				
Rhizodus hibberti ? ,,			*				

Fossil Plants from the Millstone Grit Rocks.	Kinder Grit.	Third Grits.				Rough Rock and Flagrock.
	K	D	C	B	A	R
Calamitina varians Sternb.		*		*		*
Stylocalamites suckowii Brougt.		*		*		*
Calamites sp.?	*	*		*		*
Lepidodendron obovatum Sternb.	*	*		*		*
,, *aculeatum* ,,	*	*	*	*	*	*
,, *lycopodioides* Sternb.	*	*				*
,, sp.?	*	*				*
Sigillaria tessellata	*	*		*		*
,, sp.?	*	*			*	*
,, ,,		*		*		*
,, ,,						*
Stigmaria ficoides	*	*	*	*	*	*
Halonia regularis				*		*
,, *tortuosa*		*		*		
Knorria						*
Ulodendron				*		*
Megophyton frondosum		*				*
Dadoxylon	*	*		*	*	*
,, with structure		*				
Sternbergia = *Artisia approximata*	*	*	*	*		*
,, *transversa*		*		*		*
Cordaites principalis		*				
Mariopteris muricata		*				*
,, *nervosa*		*				*
Neuropteris gigantea		*				
,, *hetrophylla*		*				
Alethopteris lonchitica Schl.		*				*
,, *aquilina* Phil.						*
Pecopteris						*
Sphenophyllum		*				
Caulopteris sp.?						*
,, ,,				*		
,, ,,				*		

ON SOME FOSSIL FISH FOUND IN THE MILLSTONE GRITS OF YORKSHIRE.

BY EDGAR D. WELLBURN, L.R.C.P.

(*Read June* 10*th*, 1898.)

PLATE LX.

On January 27th, 1874, Mr. John Aitken, of Bacup, read before the Manchester Geological Society a paper on some fossil fish-remains he had found in the Millstone Grit series at Wadsworth Moor, near Hebden Bridge. They were found during the execution of the works carried on by the Halifax Corporation for conveying water from Widdup valley to that town by a tunnel excavated through Wadsworth Moor in the direction W. and E., and at a depth of 384 feet from the surface. At this horizon a bed of fine black laminated shale was encountered, having all the appearances and characters of a true Coal Measure shale. On splitting this shale the surfaces revealed the presence of multitudes of fossils, some being very perfect, others fragmentary, Goniatites and Aviculo-pectens prevailing. The shale also contained a number of nodular concretions, and from these the largest number of the fish-remains were obtained, a few others being found in the shale itself.

[*] *Section showing the exact position occupied by the fossiliferous shale.*

No. I.	Grit.—Rough Rock	100 feet.
	Shales	300 feet.
No. II.	Grit.—Grey Grits of Rocking stones...	80 feet.
	Shales	350 feet.
No. III.	Grit or Galliard rock with Coal strata	100 feet.
	Blue Shales (fish in thin shales 200 feet from the top)	450 feet.
No. IV.	Grit.—Pebbly Grits	120 feet.
Yoredale strata	... ...	600 feet.

On November 14th, 1896, Prof. P. F. Kendall, F.G.S., and Mr. A. Slater, B.Sc., found in some dark shales at the base of the Middle Millstone Grit (probably the same as the Third Grits of Mr. James Spencer) a slab containing the remains of two genera of fish, viz., *Acanthodes* sp.? and *Acrolepis Hopkinsi* McCoy.

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[*] After the late Mr. James Spencer.

Again, in the present year, Mr. Thomas Saltenstall, of Sowerby, sent me a fin-spine that I am unable to distinguish from *Acanthodes Wardi* Egerton. He found it in some dark shale also, at the base of the Third Grit, at Boulder Clough, Sowerby.

And quite recently I found in the collection of the late Mr. James Spencer, of Halifax, a slab showing Acanthodian remains, which had been found in the shale at the base of the Third Grit at Kilnhouse Wood, Luddenden Dean, Luddenden.

From the above it will be seen that up to the present time all the fish-remains have been found at one horizon, viz., in dark shales near the base of the Third Grit, and as far as I know this is the only horizon at which they have been found in the whole of our Millstone Grit series.

Remarks on the Fish-Remains Found.

Sub-class: Elasmobranchii.
Order I.: Ichthyotomi.
Family: Cladodontidæ.
Genus: *Cladodus* Agassiz.

Sp. *Cladodus* sp.?

Teeth: Loc., Wadsworth Moor.

Order II.: Acanthodi.
Family: Acanthodidæ.
Genus: *Acanthodes* Agassiz.

1. Sp. *Acanthodes Wardi* Egerton.

Fin-spine having the following characters:—Scythe-shaped, much laterally compressed, with a faint groove and ridge parallel with the anterior border, and disappearing distally; distals flattened.

2. *Acanthodes* (*Wardi* Egerton?).

Fragment of fish, showing the body from immediately in front of the "Branchial arches" to about three-quarters of an inch behind the dorsal fin.

The body is much flattened and covered with patches of small quadrate granular scales, which are smooth and faintly hollowed mesially.

EXPLANATION OF PLATE LX.

Fig. 1. *Acrolepis Hopkinsi* McCoy. Head, natural size. P.—Parietals. F.—Frontals. E.—Ethmoid. Sq.—Squamosal. SO.—Supro orbital. Or.—Orbital region. PMx.—Premaxilla? crushed backwards into orbit. Mx.—Maxilla. Most of the bones show the "tubercular ornamentation" in impression. From the Millstone Grit, Wadsworth Moor. Specimen in the Woodwardian Museum, Cambridge.

Fig. 2. *Acrolepis Hopkinsi* McCoy. Part of under surface of head. Br.—Branchiostegal rays, the "tubercular ornamentation" shown in impression. ICl.—Infraclaviculars. Cl.—Clavicles. From Millstone Grits, Wadsworth Moor. Specimen in the Woodwardian Museum.

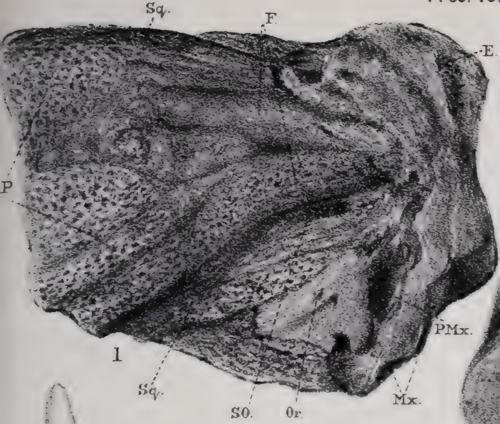
Fig. 3. *Acrolepis Hopkinsi* McCoy. Part of body showing scales and part of left clavicle? (Cl.). *3a*. Flank scale enlarged. *3b*. Under surface of scale. From Millstone Grit, Wadsworth Moor. Specimen in the Woodwardian Museum.

Fig. 4. *Acanthodes Wardi* Egerton. Fragment of fish. P.F.S.—Pectoral fin spine. V.F.S.—Ventral fin spine. V.F.—Part of ventral fin. A.F.S.—Anal fin spine. D.F.S.—Dorsal fin spine. S.—Scales. 4*a*. Group of scales magnified. From the Millstone Grit, Eccup. In the author's collection.

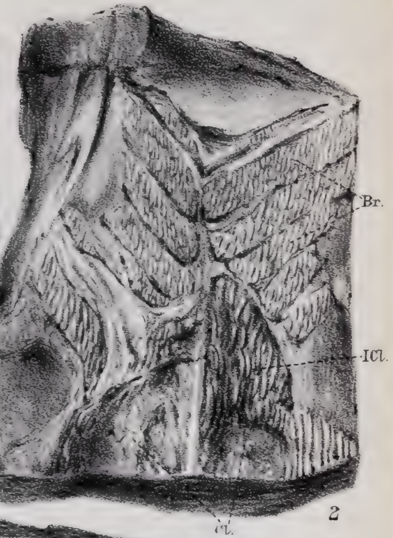
Fig. 5. *Acanthodes Wardi* Egerton. Fin spine (pectoral?) natural size. From the Millstone Grit, Sowerby. In the author's collection.

Fig. 6. *Cladodus* (*Mirabilis* Agassiz?). Imperfect tooth magnified. From the Millstone Grits, Wadsworth Moor. Specimen in the Woodwardian Museum.

NOTE.—Unfortunately it is only since the completion of my paper that I have, through the kindness of Prof. T. McKenny Hughes, F.R.S., and Mr. F. R. C. Reed, M.A., had the pleasure of seeing and figuring the above specimens.



1



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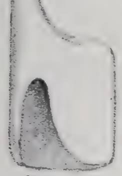
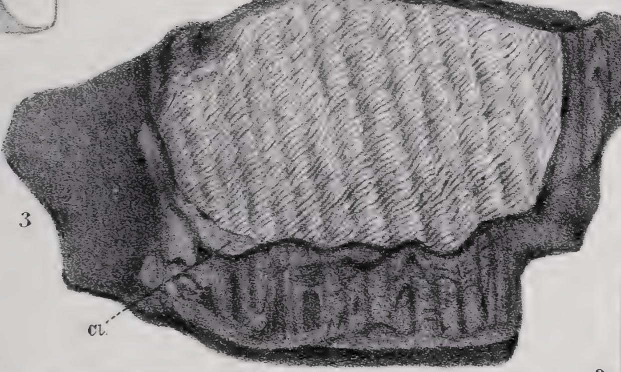


3b



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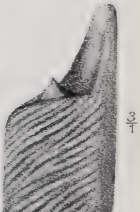
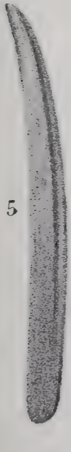


3a



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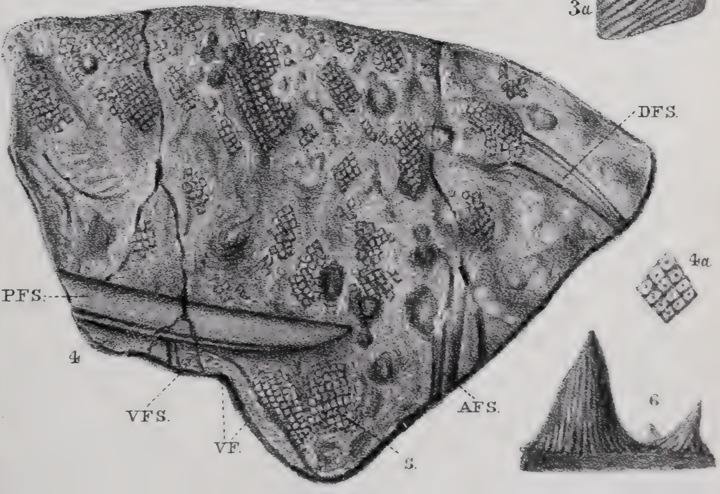

4

4a

6

Branchial Region is shown, but the five calcified gill arches are not well marked.

Fin-spines. The *pectoral* is well shown, being broad, robust, somewhat laterally compressed, and shows a faint groove and ridge parallel with the anterior border, disappearing distally. The spine being displaced upwards and backwards into the body, the fin is not shown.

Ventral.—The basal part of this spine is shown, and there also appears to be a faint indication of the basal part of its fin? The spine is situated at a point "about one-third nearer the pectoral than the anal spine."

Anal.—Only the basal part of this spine is shown.

Dorsal.—Well shown at a point slightly behind the anal spine; it is slightly less than half the size of the pectoral spine, is not so much laterally compressed, is somewhat tumid proximally, and shows a well marked groove and ridge parallel with its anterior border. No fin is shown, the spine being compressed downwards and backwards into the body.

Determination of species seems to rest between *A. Wardi* Egerton and *A. nitadus* A. S. Woodward, and I refer the specimen with some hesitation to the former, considering the character and position of the ventral fin.

3. *Acanthodes* sp.?

Mr. Aitken mentions part of the body and scales of this genus, the species being doubtful.

4. *Acanthodes* sp.?

The specimen shows two fin-spines—probably the dorsal and pectoral; also patches of scales which are very minute. The determination of species is impossible, the specimen having suffered so much from erosion.

SUB-CLASS: TELEOSTOMI.
Order I.: CROSSOPTERYGII.
Sub-order: Rhipidistia.
Family: Rhizodontidæ.
Genus: *Strepsodus* Young.

Sp. *Strepsodus* sp.?

Tooth: Loc., Wadsworth Moor.

Order II.: ACTINOPTERYGII.

Sub-order: Chondrostei.

Family: Palæoniscidæ.

Genus I.: *Elonichthys* Giebel, 1848.

Sp. *E. Aitkeni* Traquair.

Among the fossils described by Mr. Aitken, in the paper mentioned above, were the remains of a fish which he considered to belong to the genus *Acrolepis*, the species being new. This fish has since been described by Dr. R. H. Traquair, F.R.S., &c.,* he referring it to the genus *Elonicthys*, giving it the specific designation *Aitkeni*, the species proving to be new.

The remains of this fish found in the shale at Wadsworth Moor, although fragmentary, were in a beautiful state of preservation. In one specimen the head is shown (with the exception of the end of the snout), and about the anterior third of the body. The head bones are beautifully preserved, and show the beautiful and characteristic ornamentation ("undulating ridges passing at times into elongated tubercules"—Traquair). On the right side are remains of a pectoral fin ("rays unarticulated for about one-third their length"—Traquair), and on the left are several small elongated plates (branchio-stegal rays), also two larger plates which are probably opercular. The scales are rhomboidal in shape and profusely sculptured, with "ridges and furrows traversing them *almost parallel* (with their long axis?—Aitken) *with the superior and inferior borders, and nearly in a line with the body* of the fish; the ridges having a tendency to bifurcate and not unfrequently further subdivide into two or three branches, these often converging and becoming re-united." This scale ornamentation corresponds to a great extent with that given by Dr. Traquair.

Genus II.: *Acrolepis* Agassiz.

Sp. *A. Hopkinsi* McCoy.

In the Woodwardian Museum, Cambridge, are five specimens of this fish from Wadsworth Moor. Mr. F. R. C. Reed, M.A., informs me that they comprise portions of the "trunk, showing scales," and portions of the "head, showing cranial bones."

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* Geo. Mag., Dec. 3rd, Vol. III., No. 10, p. 444, 1886.

The specimen found at Eccup, near Leeds, shows a mass of scales on both sides of the slab, and probably represents the central portion of the body. The ornamentation on the scales is beautifully shown, and consists of prominent oblique ridges occasionally branching and anastomosing, or where two diverge another being intercalated between them. The interlocking of the scales is also very well shown, the anterior superior border being produced upwards in a very striking manner; the outer surface of this projection and the spine articulating with the inferior and anterior portions of the inner surface of the scale above, producing a very firm and powerful union.

NOTE.—Besides the above, Mr. Aitken mentions the following:—

1. *Ctenacanthus hyboides?* Tooth of.
2. *Rhizodus Hibberti?* Spine of?
3. *Palæoniscus*, Scales of.

The first seems to have been a tooth of *Cladodus* sp.? but of the others I can offer no opinion, as I cannot trace the specimens.

TABULAR SUMMARY OF THE FISH-REMAINS, WITH THEIR STRATIGRAPHICAL DISTRIBUTION.

	Base of the Third Grit, Wadsworth Moor.	Base of the Third Grit, Luddenden Dean, near Luddenden.	Base of the Third Grit, Boulder Clough, Sowerby.	Base of the Middle Grit, (Third of Mr. Spencer) Eccup, near Leeds.
1. *Cladodus* sp.?	*			
2. *Acanthodes Wardi* Eg. ...			*	*
3. ,, sp.?	*	*		
4. *Strepsodus* sp.?	*			
5. *Palæoniscus*?	*			
6. *Elonichthys Aitkeni* Tr.	*			
7. *Acrolepis Hopkinsi* McCoy	*			*

THE DISTRIBUTION OF MOORLANDS IN THE EAST OF YORKSHIRE, AS EXPLAINED BY THE GLACIAL HISTORY OF THE COUNTY.

BY THE REV. E. MAULE COLE, M.A., F.G.S.

(*Read July 15th,* 1898.)

If anyone will take the trouble to consult the one-inch ordnance maps of the Vale of York, for a distance of about 12 miles on either side, and mark off the number of Moors mentioned, he will be surprised to find that, while only four occur on the south side, no less than thirty appear on the north. There must be some reason for this peculiar distribution of names which I propose briefly to consider. In the first place, what is the dividing line? The terminal moraines of the two great confluent glaciers, which, in the Ice Age, occupied the upper portion of the Vale of York. The glacier on the eastern side came down from Stainmoor, and is characterised by the presence of boulders of Shap granite and Teesdale basalt; that on the west came from Wensleydale, and is characterised by the absence of the said boulders.

The Stainmoor glacier presents two terminal moraines—one running in a curved form, as all moraines do, from High Catton to Escrick and Stillingfleet; another, a few miles northward, from Upper Helmsley to York. It has been questioned which of the two is the oldest. In my opinion the glacier once extended as far as Escrick, and subsequently, in shrinking, left a second moraine at York. This is in accordance with such moraines as I have had opportunities of examining in Switzerland and Norway.

The Wensleydale glacier left only one terminal moraine extending from York through Bilbrough to Healaugh.

If the inquirer takes his station on the road from York to Stamford Bridge he will find that he is on a ridge some fifty or more feet higher than the surrounding land. To the north there is a dead level, to the south one somewhat similar. Really, he is on the terminal moraine of the Stainmoor glacier.

What has planed down the whole country northwards, and left so many places designated as moors? This is the question? I have little hesitation in answering, the glacier did it. It easily removed the surface soil; and the subsoil, consisting of New Red Sandstone, offered no resistance. In the process little Boulder Clay was deposited, because the mud was constantly carried away by the streams which flow under all glaciers, and there was nothing to check the escape of the muddy water. It seems to me that Boulder Clay can only, as a rule, accumulate in hollows, or where for some reason the mud cannot escape and has time to settle, as, for instance, in Eskdale and in all the pre-glacial valleys, in fact, on the coast facing the icewall which then existed, or between a moraine and a line of hills, as in the rear of Sheriff Hutton. The centre of the Vale of York to the north was washed clean, and nothing but sand left behind, which constituted a most unprofitable soil, whereas to the south, in front of the moraine, a good deal of mud was dropped and mixed with the soil, creating a sort of loam which was more productive.

It is in this way that I venture to explain the presence of moors in the north, and their absence in the south, of the York moraine.

List of Moors.

1. North.—Heworth, Murton, Holtby, Huntingdon, Stockton, Earswick, Common Moor, Haxby, Strensall, Wigginton, Tholthorpe, Rawcliffe, Clifton, Skelton, Hall Moor, Sutton, Moxby, Brown Moor, Ox Moor, Helperby, Hag Moor, Myton, Aldwarke, Youlton, Newton, Marston, Poppleton, Acomb, Moor Monkton, and Scagglethorpe.

2. South.—Barmby-on-the-Moor, Holme-on-Spalding Moor, Ross Moor, and Ox Moor.

BRUNANBURH. BY REV. E. M. COLE, M.A., F.G.S.

(*Read July 15th,* 1898.)

If there is any one subject more than another which, for hundreds of years, has exercised the ingenuity of antiquaries, it is perhaps the lost site of the battle of Brunanburh, in A.D. 937, by which Athelstan consolidated his kingdom. In speaking to my friend, the late Canon Raine, on the subject, he said that it was a hard nut to crack, and probably hopeless. The name of the place is utterly lost, and no two authorities agree as to its orthography. Without presuming to say where it was fought, I have a very strong opinion as to where it was *not* fought. I venture to say, notwithstanding various arguments which of late years have been brought forward, that it was not fought in the East Riding.

Let us consider the situation of affairs, and we cannot do better than take Egil's Saga for our guide, because it is unprejudiced, as written by a Norseman, and compiled from facts handed down from one who had taken part in the battle, and been, in fact, one of the principal commanders. I would first remark that the writer says Olaf instead of Constantine, an easy mistake for a foreigner, when we remember that Anlaf was Constantine's son-in-law.

In the Rev. W. C. Green's translation of Egil's Saga, Chapter LII. begins as follows:—

"Olaf, King of Scots, drew together a mighty host, and marched upon England. When he came to Northumberland he advanced with shield of war. On learning this, the earls who ruled there mustered their force and went against the King. And when they met there was a great battle, whereof the issue was that King Olaf won the victory; but Earl Gudrek fell, and Alfgeir fled away, as did the greater part of the force that had followed them, and escaped from the field. And now King Olaf found no further resistance, but subdued all Northumberland."

If all Northumbria was subdued, naturally its capital, York, was in the hands of the invaders, and we must put away any idea that Athelstan marched from York to Beverley, as suggested by Mr. C. S. Todd, to meet an army encamped at Brough. Besides, this is making him come in the wrong direction—since it is stated over and over again that Olaf advanced from the north and Athelstan from the south, e.g., "North of the heath stood a town. There in the town King Olaf quartered him, and there he had the greatest part of his force," and "From day to day Athelstan's men said that the King would come, or was come, to the town that lay south of the heath."

Neither could Athelstan be at Beverley on his way to regain Northumbria, as Mr. T. Holderness suggests. Athelstan was at Beverley *after* the battle (how long after we do not know), not *before*. He had been at Beverley a few years before on his way to Scotland, and had then sent his army straight to York, whilst he himself crossed the Humber; but he would never have dreamed now of transporting an army across the Humber, especially with the knowledge that 600 hostile vessels were ready to oppose him.

No—we may be certain that Athelstan advanced from the south, and by land, and that his objective was probably York. In that case he must follow the only existing road, the Roman road, from Lincoln through Doncaster, Castleford, and Tadcaster. It is somewhere on this line that the battle must have been fought, for the confederates were much in the same position. They had heard of Athelstan's preparations and wished to meet his advance, and this they could only do by marching south by way of Tadcaster. Already masters of Northumbria, they were probably massed at York. The Scots had arrived by land, Anlaf and his other allies by Humber mouth. Where Anlaf landed we know not, but it is very improbable that he took his ships up the river Hull to Emmotland, as Mr. T. Holderness supposes. The river would not hold them, and there was no earthly reason for their going there. The probability is that they made for the Ouse, and landed their men off Wharf Mouth or Stillingfleet, within easy reach of York. I fancy Mr. Holderness is misled by the word "Eamot." He quotes Roger, of Howden, as saying that a treaty was signed between Athelstan and the confederates "at a place which is called Eamot," and he thinks that Eamot must mean Emmotland in Holderness. On the contrary, I am of opinion that Eamot is a corruption of Elmete. We know that Athelstan had a palace at Sherburn-in-Elmete, and often resided there. It is not far from the Roman road from Castleford to Tadcaster, and only a mile from a place in the parish called Huddleston, which is said to derive its name from Athelstan. Here, it may be observed, is a vast camp of fifty acres, surrounded by entrenchments, which I have often explored. What more likely than that the conqueror signed a treaty of peace at his dwelling in Elmete? As if to corroborate this, it is a remarkable fact that, after the battle, Athelstan gave the manors of Sherburn-in-Elmete and Cawood to Holy Church, in thank-offering for his victory. The Archbishops of York became henceforth Lords of the Manor. May it not be that the battle of Brunanburh was actually fought in the neighbourhood—at Hook Moor, for instance, or Bramham Moor, or even Towton, whose river ran with blood many centuries after? History often repeats itself. At all events, this is the line of country where we might naturally expect the two contending armies to meet, and not in the East Riding.

I have only one further observation to make, and that in reference to a correspondence which I have recently had with Mr. Napper, of Sussex. He adopts the view that the battle was fought in the East Riding, beginning at Burnby, and crossing the wolds to Brough on the Humber. In this he imitates Mr. Todd. But he ignores the fact that Athelstan advanced not from the north, but from the south. Moreover, he points to the tumuli on the wolds as indicating the scenes of the struggle. I had therefore to explain to him that the tumuli are of far more ancient date, and had nothing whatever to do with the battle in question, as all archæologists will allow. Whether trenches filled up with "thousands" of dead bodies are any evidence, I cannot say. I do not know of them, and can only make allowance for exaggerated reports. Anyhow, the tumuli are, to my knowledge, built on a regular plan, and are no indication of a battle-field. I may be allowed to add that "Howe Hill" is a common designation for a tumulus, and has no reference whatever to the Welsh King, Howel Dha, as suggested by Mr. Todd.

THE SO-CALLED BRITISH HABITATIONS ON DANBY NORTH MOOR.

BY J. R. MORTIMER.

(*Read July* 15*th*, 1898.)

These lines of excavations are the most regular in size and arrangement of any I am acquainted with, and, reveiwed as a whole, they seem to have a greater claim to be the remains of pit-dwellings than any other group which has come under my observation.

Nevertheless, the application of the pick and the shovel is the only reliable means likely to determine their original use.

The first published description of this and other neighbouring groups of pits is by Dr. Young, in 1817,* of which the following is an abstract:—

"These three clusters of pits have all the same form and appearance, but other three have been discovered in the district, differing from them very materially. The most singular is on Danby Moor, between Danby Beacon and Wapley. Here the pits are also round, but, instead of being scattered about irregularly, they are arranged in two parallel straight lines; and the earth dug out of the pits at their formation, instead of forming a border round each pit, has been taken to form a wall or a fence on the outside of the lines, so that two walls run parallel to the two rows of pits throughout their whole length, inclosing the pits between them. The pits are not placed in the zigzag form, but opposite each other; and while the outer margin of each row is close to the vallum (i.e., bank) on the outside of it, there is a vacant space between the rows. These double lines of cavities, with their enclosing walls, are not all in one spot, in the same continued lines, but are found partly on one side of a hollow or valley, with a stream running through it, and partly on the other. The stream runs from south to north, or rather from south-west to north-east; and the lines on both sides are nearly at right-angles to it. Those on the east begin on the verge of the sloping bank on that side of the valley, and extend eastwards above 100 paces. In this range are 28 pits, 14 in each row. The breadth of the whole range is about 50 feet, including the walls on each side. The breadth of each pit is about 10 feet, which is nearly the distance between one pit and another. Beyond this range, 100 paces to the south-east, is the commencement of another, containing only 6 pits, 3 in each row,† yet having a wall on each side like the other. But the principal collection is on the west side, commencing at about 150 paces from the western edge of the valley, and extending westwards to a great distance. This collection, which is not exactly in a line with the first range, being a little south, is composed of two ranges: the one 130 paces in length, comprising 30 pits, 15 in each row; the other about 140 paces, containing 34 pits, 17 in each row. These two ranges are nearly in a line, an interval of 25 paces being left between them. They are a little broader than the first range, a wider space being left between the rows of pits, which are enclosed by the same kind of low earthern walls on the outside. There are no walls at the ends of any of the ranges, these being left open, apparently with a view to admit of additions. The most westerly range, which is also the largest, is distinguished by this peculiarity: that near the middle of the south row we find instead of a pit, a circular space, 35 feet in diameter, enclosed by the low wall on this side, which here projects in a semicircle outwards, and another semicircle inwards, to form this circular space; the centre of which is, therefore, not in the line of the pits, but in the line of the wall."

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* Young's *History of Whitby*, Vol. II, p. 672.

Secondly, in the *Gentleman's Magazine* for 1861, in an article on encampments and earthworks, this series of pits is also referred to as under:—

"The most interesting and instructive site (speaking of pit settlements) is that on the Danby Moors. For the following account of this remarkable spot I am partly indebted," says the writer, "to a MS. report of an investigation by a party of gentlemen 12 or 14 years since" (about 1846), "but not less to my own personal and repeated examinations. The site consists of a collection of pits. These pits are circular in form, and divided into separate groups; but every group is arranged in two parallel lines—pit over against pit; an arrangement which is deviated from, in one or both particulars, in other sites, both here and elsewhere.

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† These are not shown on the Ordnance Survey.

"All of these excavations have been from 4 to 5 feet deep, as compared with the present surface of the surrounding moor; all of them paved at that depth with stone, and probably rough-walled with uncemented stone within as well, and from 10 to 12 feet in external diameter. (These measurements were obtained from the explorations made by the Whitby gentlemen previously referred to.)

"There are two principal groups:—One (No. 2 on the map) composed of two members, or streets, not in exactly the same straight line, and with an interval of 25 feet between their terminations; the other (No. 1 on the map), which lies beyond a small stream, and on the verge of the slope towards it, is smaller in dimensions. It contains 30 or more pits. About 100 yards to the south of this is the supposed commencement of another. This contains six pits. Some, it is supposed, have become indiscernible through lapse of time and its effects. The one upon the further or western side of the stream (No. 2 on the map) is larger, and numbers 68 excavations in all—30 in one division and 38 in the other. This range is broader by some feet than the eastern group, which is 50 feet from side to side. That measurement includes the walls, formed of earth heaped over stones and fragments of rock, and each two to three yards thick, which encloses the sides of each group of pits. In the larger sub-group of the western division one of the excavations (see Fig. 1) in the south row is of much greater dimensions than any other in the assemblage, being not less than 35 feet in interior diameter; and on coming to it the enclosing wall, which, if continued, would pass through its centre, sweeps round it in a semi-

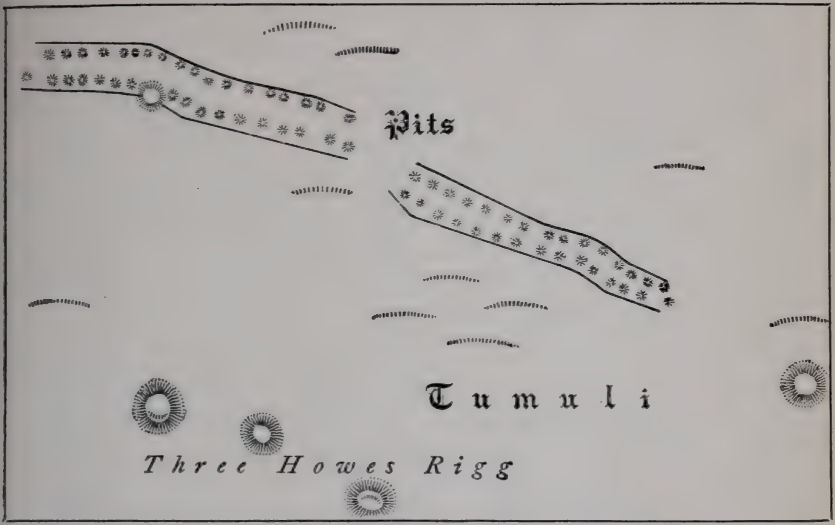

FIG. 1.—THE BRITISH SETTLEMENT ON DANBY NORTH MOOR FROM THE 25-INCH ORDNANCE MAP.

circle and then continues its rectilinear course. But the enclosure of the pit in question is completed by the addition of an interior semicircular wall. This interrupts the regularity of the 'street' in this case. In each of the other groups the 'street' is perfectly straight and even. The ends of the rows or so-called 'streets' are open in every case; although in one instance the two pits at the end are placed nearer each other than the remaining ones, so as to contract the entrance to the interior. If all were placed end to end, the total length would be from 1,200 to 1,300 feet."

Thirty years later, Canon Atkinson, the writer of the previous article—after having, it may be supposed, obtained new facts and further information on the subject—like a true philosopher, changes his views, as in his *Forty Years in a Moorland Parish*, published in 1891, he abandons altogether the pit-dwelling theory, and assigns almost every group of pits to mining operations, and at p. 175, in specially referring to the pits now under discussion, says:—

"Even at the British village on our Danby North Moor, between the Beacon and Waupley—perhaps honoured with more pilgrimages than any other on the list—the tale-telling map places a seam of 'impure ironstone' inconveniently close by. And yet this is the one, of all others, the circumstances and surroundings of which admit of most doubt as to their original intention or *raison d'être*. For they are not only not arranged in more or less quincunx order as the rest are (or have been), but they are in two parallel rows, and apparently with an intended outside bank or projection. They have never been properly examined, or indeed subjected to any process of exploration that would satisfy the merest tyro in such inquiries; for the recorded examination already referred to was, as a scientific examination, altogether delusive. True, the inevitable 'bottom' and the inevitable 'charcoal' were found, and the burnt stones, and so forth. But the full and convincing investigation remains to be made; and from my own personal experience on the spot, I am disposed to think that when the true bottom is found the British village theory will be disposed of for good."

At p. 174 Canon Atkinson remarks—

"For my own part, if only the opportunity could be achieved, I should go in for an examination of any of those so-called British villages with very definitely preconceived opinions as to what should be looked for, and the way in which the looking for it should be conducted; and, for one thing, I should have no more doubt about finding horizontal operations than about the fact that the pits were there. If I did not find the ironstone it would be because it had been removed."

This is strong faith, without the least attempt to verify it. Being desirous of personally inspecting these pits, I took the train to Lealholm Station on August 28th, 1893, in company with Dr. Wood, of Driffield, and then walked to Danby North Moor.

Though we were supplied with a 6-inch Ordnance map, on which the pits were very distinctly shown, after traversing the moor in various directions, we were much disappointed in not being able to find them. On July 4th, 1894, in company with Mr. C. H. Read, of the British Museum, and Mr. T. Boynton, of Bridlington Quay, I was more fortunate. We found these pits to be very uniform in size and arrangement, considering that they were much encroached upon and partially filled in by the growth of peat. From external appearances their age seemed uncertain. Though my two colleagues thought they might not date back more than two or three centuries, I am inclined to think that they are much older.

After our return, I informed Canon Atkinson of our visit, and expressed my surprise that some antiquary interested in those pits had not during the last twenty years attempted to settle their origin by carefully cleaning out two or three of them. I received the following reply:—

"The pits you refer to were dug into by and in the presence of a large body of wise men of Whitby, some fifty years ago, and a long report of the exploration of the pits, and of the adjacent howes, drawn up and presented to the then Lord of the Manor, and by his son, the Lord Downe, was handed over to me. I have it still, and I can say of it that it is *absolutely valueless*. Many years ago I did something towards an investigation, and soon convinced myself that these wiseacres had not reached the bottom, as they said they had. I proposed to Mr. Greenwell (as he was then) to come over and join me in a thorough examination of their nature. Circumstances at the time intervened to prevent the scheme, and I need not tell you, who have seen them with the water standing in them, that it is not every year, if any, that investigation is easy, or indeed possible. I chose a dry year; yet not more than three or four permitted deeper digging than 1½ to 2 feet. When that depth was reached, water began to stand in them. I do not seem to think that they would have been very comfortable or healthy residences under such circumstances."

Believing that nothing less than a further and careful application of the pick and shovel in the hands of an experienced workman would give any certain clue to their age and purpose and dispel these contradictory reports, I wrote a letter to Canon Atkinson on May 20th, 1895, an abstract of which I give below.

"I have just read your account of the Danby North Moor group of pits, in your very interesting book *(Forty Years in a Moorland Parish)*, and I have the same doubts as to their origin as you seem to express at p. 175. To endeavour to clear up this doubt it does seem to me most desirable that two or three of the Danby North Moor Pits should be emptied by an experienced workman. I therefore beg you will excuse me taking the liberty of saying that if you will kindly obtain permission to excavate, say two or three pits, I will undertake to send (supply) a competent workman and pay all expenses."

I was disappointed in receiving the following reply, dated May 25th, 1895:—

"Dear Sir,—Viscount Downe absolutely prohibits any such tampering with the pits on Danby North Moor as that suggested in your letter to me, and desires that the manorial officers should be warned against any possible attempt of the kind. From my last letter you would see that, so far as your project was intelligible to me, I am heartily at one with his lordship.

"Faithfully yours,

"J. C. ATKINSON."

To this I answered—

"May 29th, 1895.

"Dear Sir,—I beg you to excuse the trouble I have given you in writing about the pits. I feel I must apologise for not making the matter more clear to you in my letter of the 20th inst. What I meant, and what I should have said, was I would *take* a competent workman—not send one. Of course you would have had an opportunity of being present, and also Canon Greenwell and anyone you desired to see the excavation. Perhaps I seemed to you to put too much reliance on 'a competent workman,' but no stranger to such work would be likely to distinguish the limits of the original pits; hence the probability that he would, unknowingly, break into the sides and bottom of the pits, and so their true size and shape would not be ascertained. No antiquary would wish to remain in the interior of the pits all the time the work was going on; therefore an experienced workman should be employed—of course under proficient supervision. Your knowledge of this kind of work for over forty years, and my experience (without any theory to support) for more than thirty years, should be something better than tampering with the pits. The next generation even may not be able to supply much longer experience than ours in this matter. Again apologising for the trouble I have given you,

"I remain,

"Yours truly,

"J. R. MORTIMER."

After this refusal I thought that the next best thing would be to revisit and carefully examine the pits, in company with my friend, the Rev. E. M. Cole, F.G.S., of Wetwang, whose knowledge of earthworks in general is well known. On July 8th, 1896, Mr. Cole and I visited these pits, and the following is Mr. Cole's opinion:—

"On July 8th, 1896, I accompanied my friend, Mr. J. R. Mortimer, to make an inspection of the pits on Danby North Moor. By an unaccountable order of Lord Downe, the owner of the manor, we were debarred from making any excavation, which is the only possible method of obtaining a correct result. Seeing that the pits in question are on an open moor, far from any human habitation, it seems absurd to suppose that any harm could be done by emptying a few of them of the sludge which in course of ages has collected in them, for the purely scientific purpose of trying to ascertain their origin. But I do not wish to blame his Lordship; I think he has been unwisely influenced, and would withdraw his opposition were the matter laid properly before him.

"The difficulty was to find the pits. From Danby Station you must first find your way to Beacon Hill, N.E. This is easy enough. Then a mile away over ling and heather, N. by E., you must direct your course for three 'howes,' which stand on a ridge between two hollows on either side excavated by incipient streams. About a hundred yards to the north of the howes are the pits which are the subject of this memoir. They have been so correctly described by preceding authorities, narrated above by Mr. Mortimer, that little information is wanted here. My own opinion is all that is asked, but this is no easy matter to give. The pits were filled nearly to the top with a black-looking sludge, in which grew rushes. There was every indication of abundance of water, though the weather for a long time had been exceptionally dry. It seemed to me that if the pits had been emptied of sludge they would quickly have been filled with water. Under such conditions the idea of their having been habitable seems absurd. But when they were excavated might not the moor have been forest, and the climate different? Possibly, but the more forest the greater rainfall; so that does not help us.

"What is meant by being 'paved with stone' at the bottom?* The geological formation shows a thin bed of Kellaways sand-rock resting on Cornbrash. The Cornbrash is limestone, and the only limestone available for a long distance. Could the limestone have been quarried for smelting purposes? But as the limestone comes nearer the surface, a few yards south of the howes, one would think that would have been the more suitable place for obtaining it. But the said limestone is also ferruginous, and has been worked in various places, though with little success, for iron. True, but the same remark applies as before: Why not have sought the ore where it comes to the surface? Still, it is an important fact to bear in mind, in considering the origin of the pits, that both iron and lime could be obtained there, and to my mind the probability that this is the true explanation is very great. It follows that the pits need not be very ancient. If something more fanciful is sought for, at all events let the habitation theory be discarded, and then consider the following brilliant suggestion now invented for the first time:

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* See page 408.

"As nothing but hoary antiquity will suit, imagine a body of ancient Britons with flint-tipped arrows and bronze daggers issuing from their wigwams which clothed the sides of Roseberry Topping, and making for the vast forest which covers the hills to the east and conceals amid its gloomy recesses the burial mounds of their more gifted chiefs. It is a hunting expedition. Their object is to capture the wild animals--deer or blue hares which inhabit the forest, and so provide food for their little ones and pit-holds. For this purpose they have skilfully constructed a series of pitfalls extending across some rising ground from one slight valley to another, in the immediate neighbourhood of three recently-erected howes, and moreover concealed the approach by earthen banks on either side, so that when the affrighted animals leap the bank they shall fall unconsciously into, &c.

"If this fails to satisfy, I have nothing more to add."

My doubts as to the origin of these pits being still as strong as those of Mr. Cole, I decided to make, at the first opportunity, a clandestine examination of them. Therefore, on July 19th, 1897, I, in company with an assistant, revisited these pits. This time I was supplied with a pointed steel rod, for the purpose of probing them, believing we should do no more harm to the heather-clad moor than would be done to a rick of hay by pricking it with the point of a needle. Though this proceeding was much less satisfactory than would have been the application of the pick and the shovel, we obtained results which, to a great extent, may be relied upon.

We probed and measured five pits situated in different places in the group with considerable care, and their close uniformity in size is shown by four having a depth of 4½ feet and the fifth of 4 feet. In each pit the probe (steel rod) reached the hard, undisturbed rock at the bottom. To make allowance for the crumbling in of the edges of the pits, we took two opposite diameters of each pit, and in every instance by measuring from the edge of the pit where the probe reached the firm rock at a depth of 18 inches. From these points the diameters of the pits ranged from 9½ to 11½ feet.* This group of pits, consisting of two rows similarly arranged, is distinctly different from the single lines of small pits forming the groups on Alliston Moor, in the neighbourhood of Scamridge Dykes; and it differs from the group known as the "Killing Pits," on the north-west brow of Goathland Moor. Both these groups have been described by me in the *Proceedings of the Yorkshire Geological and Polytechnic Society* (Vol. XIII., 1896).

Mr. Cole's pitfall theory seems at first sight a plausible one, but for such a purpose the wide opening or gate-ways shown crossing the group near the centre presents a decided objection.

Neither is the situation near the foot of the sloping ridge well chosen, as the animals would have been much more readily forced into pitfalls situated in the hollow ground (small valleys) through which run little streams of water near the ends of the line of pits, as shown on the accompanying map (Fig. 2). Besides, the pits in the two lines should not have been planned diametrically opposite, as they really are, so as to give a clear passage straight between two pits in both lines. Moreover, the bank of earth—traces of which still remain—fencing the pits on both sides is, I think, fatal to their having been constructed to drive wild animals into. On the other hand, their small and uniform depth, as well as their arrangement at regular distances one from another, in two parallel lines, would not have been adhered to had they been made to obtain minerals of any kind. Besides, there is no mineral worth excavating.

Therefore, if we must admit these objections against their suggested origin, for what purpose were they made? The old belief that they were pit-dwellings Canon Atkinson at one time very strongly supported,* and—as we must believe—from what he considered reliable evidence. However, it will have been observed that later he firmly opposed this view. His chief objection seems to have been that these pits are mostly in a swampy condition. Why did he not observe this during his early studies of these pits and at the time he so ably pleaded their habitation purpose? Might it be because the pits were then less charged with slushy peat than now? This is very probable; and it is quite possible that, through some different surface conditions existing when the pits were dug, the peat had not even commenced to form, there being then nothing (as hinted at by Mr. Cole) to prevent the natural drainage of the sloping surface, which consequently might be firm and dry. In this case we must assume the growth

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* These measurements closely correspond with those given by Mr. Atkinson (as he then was), the writer in the *Gentleman's Magazine* for 1861, which I quote at p. 407. These are the measurements obtained during the excavations made by the Whitby gentlemen quoted, and then believed in by Mr. Atkinson in 1861, though afterwards he stigmatised these same as "wiseacres."

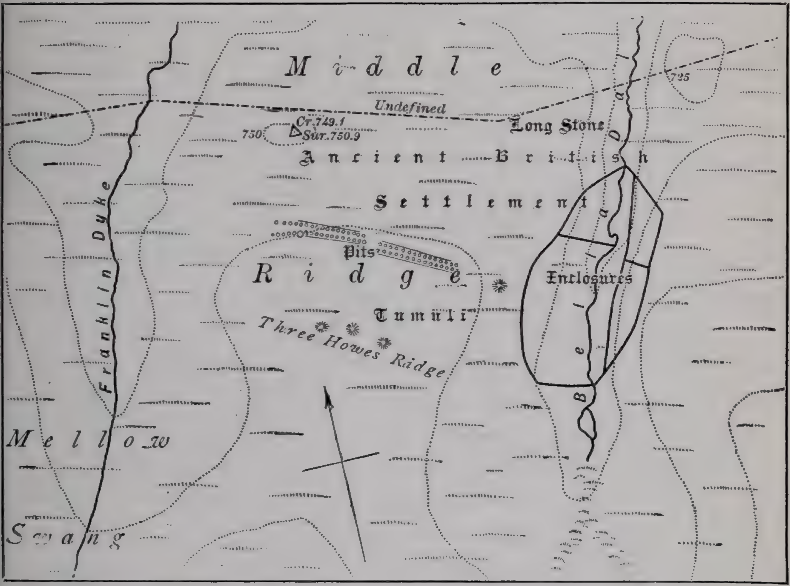

FIG. 2.—THE BRITISH SETTLEMENT ON DANBY NORTH MOOR FROM THE 6-INCH ORDNANCE MAP.

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* See his anonymous paper in the *Gentleman's Magazine* for 1861.

of peat to have taken place afterwards. Such an instance is given by the Rev. H. H. Hutchinson, in *Prehistoric Man and Beasts*, p. 26. He alludes to a bed of peat, 5 to 6 feet in thickness, that had accumulated over a pavement of small stones in the centre of a small circle at Moyness, in Nairnshire. Other instances of a similar kind could be given.* That these pits now hold surface water is mainly due to the growth of heather and peat, which in this case is probably of somewhat modern accumulation. Taking all the evidence into consideration, I am now—though in the absence of positive proof—strongly inclined to believe—at least, until further evidence is obtained—that this series of pits (unlike many others) was an assemblage of primitive habitations. The site is a well-chosen one, near the foot of a low ridge (Three Howes Rigg), between two small streams of water. The diameters of these pits are of convenient size for being roofed by placing round their edges branches of trees, leaning inwards and meeting at the top. Their depths also are just such as would enable an adult to tumble in and scramble out unaided by mechanical assistance.

Most probably their interiors would be lined by small twigs and dry grass, making them places of warmth in winter and cool retreats in summer—just such places as would well serve a small community of primitive hunters living mainly in the open air.

That these pits were contemporaneous with the contiguous howes, and that under these barrows now rest the remains of the chiefs of this early settlement is not improbable.

The conclusion derived from the exploration made by what Canon Atkinson terms "the large body of wise men from Whitby" I believe to be the true one.

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* Several occurrences are given in *Loch Etive*, by A. Smith.

FISH FAUNA OF THE LOWER COAL MEASURES OF THE HALIFAX AND LITTLEBOROUGH DISTRICTS.

BY EDGAR D. WELLBURN, L.R.C.P.

PLATES LXI. AND LXII.

(*Read November 17th,* 1898.)

INTRODUCTION.

My reasons for considering the "Fish Fauna" of these two districts together is that it may be taken for granted that the Yorkshire and Lancashire coal fields were joined and continuous until they became separated at the close of the Carboniferous period by the upheaval which caused the Pennine anticline.

The Halifax Coal strata forms a compact group of rocks, consisting of beds of shale, sandstone, rag, bind, seat-earth, gannister, ironstone, and fossiliferous beds of marine and fresh water origin, the whole forming that portion of the Lower Coal Measures which is enclosed between the Rough Rock at the base and the Northowram and Elland flagrock at the crown.

The *conditions attending the formation* of the different beds were of a very varied character, the area being sometimes a land surface at others a great estuary, inhabited by mollusca and fishes, and into which the sea occasionally erupted, bringing marine shells and fishes.

I have found the majority of the fish-remains in a very thin layer of shale lying *directly on* the Hard Bed Coal. Immediately above this point there is a bed of Marine Shells (Aviculo-pectens, &c.), from 3 inches to 6 inches in thickness, and overlying this "pecten bed" the shale contains a large number of nodular concretions, locally known as "Baum Pots," which are composed of the carbonates of iron and lime and are of great interest, as they sometimes contain fish-remains as well as Goniatites, Nautili, &c.; the fine type specimen of *Cœlacanthus Phillipsi* Agassiz having been found in one, and another contained a fine specimen of *Acrolepis Hopkinsi* McCoy.

The Coal strata in the Littleborough district to which this paper refers is that portion of the Lower Coal Measures of Lancashire which includes the following coal seams, viz.: 40 yards Mine, Upper Foot Mine, Gannister coal, Lower Foot Mine, and Yard Mine at the base.

The conditions attending their deposition seem to have been very similar to those in the Halifax district, there being evidence of fresh water and marine conditions.

Correlation of the Coal-seams of the two districts.

Halifax District.		*Littleborough District.*
36 yards Coal †	=	40 yards Mine.†
Hard Bed Coal †	=	Upper Foot Mine.†
Middle Band Coal Soft Bed Coal †	=	Gannister Coal.
Thin Coal	=	Lower Foot Mine.†

I have not as yet found any fish-remains in the other beds, but feel confident that, with a more extended research, they will yield a fairly rich fauna.

State of Preservation of the Fossils.

With few exceptions the specimens, although fragmentary, are in a good state of preservation, and do not seem to have suffered much from "rolling or abrasion."

TABLE OF THE HALIFAX COAL STRATA.‡

1.	Flagrock	70 ft. to 150 ft.
2.	Shales and Ragstone	100 ft. to 150 ft.
3.	80 yards Band Coal and Seat-earth ...	2 ft. to 3 ft.
4.	60 ,, ,, Stone, "Quarrel" Rock, &c. ...	100 ft.
5.	48 ,, ,, Coal	8 in.
6.	48 ,, ,, Stone	6 ft. to 12 ft.
7.	Shales	28 ft.

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* This "correlation" is given on the authority of Mr. John Butterworth, F.R.M.S., of Shaw, near Oldham.

† Fish-remains are found in these beds.

‡ Taken from the paper on "The Halifax Coal Strata" by the late Mr. James Spencer, of Halifax.

* 8.	36 yards Band Coal	8 in.
9.	Shales, Bind, and 36 yards Rock	98 ft.
10.	Shales with "Baum Pots," Marine Shells, Goniatites, &c.	9 ft.
11.	Pecten Bed	6 in.
* 12.	Hard Bed Coal, with Coal Balls	2 ft. 3 in.
13.	Gannister Rock and Seat-earth	4 ft.
14.	Shales	28 ft.
15.	Middle Band Coal	10 in.
16.	„ „ Seat-earth	2 ft. to 3 ft.
17.	„ „ Stone	3 ft. to 5 ft.
* 18.	Soft Bed Coal	1 ft. 4 in.
19.	Seat-earth	2 ft.
20.	Low Bed Stone (Flags)	12 ft. to 20 ft.
21.	Shales	40 ft. to 50 ft.
22.	Thin Coal	3 in. to 8 in.
23.	Seat-earth	4 ft. to 6 ft.
24.	Rough Rock.	

TABLE OF THE LITTLEBOROUGH COAL STRATA.

1.	Sandstone, Shales, &c.	839 ft.
† 2.	40 yards Mine	1 ft. 4 in.
4.	Sandstone and Shales	190 ft.
† 5.	Bullion Coal or Upper Foot Mine	1 ft.
6.	Black Shales	36 ft.
7.	Gannister Coal	2 ft. 6 in.
8.	Shales	30 ft.
† 9.	Lower Foot Mine	1 ft.
10.	Shales	50 ft.
11.	Yard Mine	2 ft. 3 in.
12.	Flagstones, &c.	215 ft.
		About 1,375 ft.

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* Fish-remains were found in these beds.

† Fish-remains found in these beds.

NOTES ON THE FISH-REMAINS FOUND.

With the exception of a few specimens kindly lent me by Mr. Magson, of Hollingworth, near Littleborough, to whom I am also indebted for the above table of strata, the following notes are based on specimens in my own collection, many of which have been seen by Dr. R. H. Traquair, F.R.S., &c., who, besides kindly naming many, also confirmed the identity of others which I had already named.

SUB-CLASS: ELASMOBRANCHII.
Order A.: ICHTHYOTOMI.
Family: Pleuracanthidæ.
Genus I.: Pleuracanthus.

Sp. *P.* (*Orthacanthus*) *cylindricus* Agassiz.

One spine from Littleborough (Lower Foot Mine) I refer to this species.

The spine is small, round, smooth, nearly straight, and 75 mm. in length, the diameter at the base being 5 mm. and at the apex 2 mm. The anterior surface is shown, the posterior denticulated surface being embedded in the matrix. The extreme tip is absent, but is shown in impression. The surface is destitute of ganoine but smooth, except at the distal end, where it is faintly striated, probably from slight wearing or erosion. The inserted portion is well shown.

Genus II.: *Diplodus.*

Sp. *D. Gibbosus* Agassiz.

Teeth from both districts. See Pl. LXI., fig. 3.

Order B.: SELACHII.
Sub-order I.: Tectospondyli.
Family: Petalodontidæ.
Genus I.: *Callopristodus* Traquair, 1888.

Sp. *C. pectinatus* Agassiz sp.

One tooth from the Lower Foot Mine, Littleborough, I refer with some hesitation to this species as, although the crown is well shown, the characteristic root is absent.

CHARACTERS.—The margin of the dental crown is low, smooth, with the cutting edge comb-like, there being twelve blunt-pointed denticles which are covered with ganoine.

NOTE.—The crown is almost identical with that of undoubted specimens in my cabinet from the Borough Lee Ironstone, near Edinburgh.

Genus II.: *Janassa* Munster, 1832.

Sp. *J.* (*linguæformis* Atthey ?).

One tooth from the Halifax Hard Bed Coal. Pl. LXI., fig. 6.

Sub-order II.: Asterospondyli.

Family A.: Cochliodontidæ.

Genus I.: *Helodus*.

Sp. *H.* sp. ?

Teeth from the Halifax Hard Bed Coal. Pl. LXI., figs. 9 and 10.

Genus II.: *Pleuroplax* A. Smith Woodward.

Sp. *P. Rankinei* Agassiz.

Teeth from the Littleborough district.

CHARACTERS.—Carina of the dental crown prominent and pitted (the result probably of abrasion, the crown being smooth when not abraded). Unsymmetrical, lateral "wings" moderately prominent. Pl. LXI., fig. 7.

Sp. *P. Attheyi* W. J. Barkas sp.

Tooth from Halifax Hard Bed Coal.

CHARACTERS.—Dental plate oval. Crown low and divided by deep transverse sulci.

Family: Cestraciontidæ.

Genus: *Sphenacanthus* Agassiz.

Sp. *Sphenacanthus* sp. new ?

The spine I refer to this genus is from the Lower Foot Mine, Littleborough district. The characters are somewhat peculiar, and do not seem to correspond with the specific diagnosis of any spine of this genus that I can find. It is most like *Ctenacanthus denticulatus* McCoy, but the general shape of the spines and the direction of the ridge ornamentation are different, also the ridges in the spine under discussion are much less numerous, non-denticulated, and smooth. From *Ctenacanthus æquistriatus* Davis, it seems more widely separated, the shape being different and also the direction of the ridges, which in *C. æquistriatus* Davis, besides being more numerous, run longitudinally parallel with the anterior margin, with the result that they die out *along the latero-posterior margin*[*] without inosculation, which is not the case in the present specimen. From the other spines of this genus it seems to be still more widely separated.

CHARACTERS.—Total length 90 mm., but the spine being broken across just below the commencement of the inserted portion, the original length was probably about 110 mm. Length of posterior border to commencement of inserted portion 75 mm., of anterior border to same point 90 mm. Diameter at commencement of inserted portion 15 mm., from this point the spine *gradually* narrows to a moderately fine point. Lateral surfaces meet in front at an acute angle; the ornamentation consists of smooth straight ridges which, at a point half way between the tip and commencement of the inserted portion, number seven, but between this point and the base the number is increased by intercalation to nine. The ridges are divided from one another by spaces about equal to their diameter. Their direction is also very characteristic; the most anterior one forms a keel on the anterior border, the next four run to the tip parallel with that border. The most posterior ridge runs parallel with the posterior border, while another runs between these two sets towards the point where they meet in front, and, lastly, on each side of this ridge are two shorter ones. The posterior surface is concave from side to side, and where it meets the lateral surface is armed by a row of well marked beak-shaped denticles, which are separated from one another by a distance about equal to their diameter at the base. Anterior to these denticles on the lateral surface and posterior to the most posterior ridge is a second row of nine small, more-rounded denticles, which are placed alternate to those on the posterior borders. The posterior border of the spine is nearly straight, but the anterior one is gently curved from base to tip. The dividing line between the inserted and excerted portions is well marked, the line cutting the anterior and posterior margins at an angle of 45°. See Pl. LXI., fig. 1, *a*, *b*.

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[*] See Quart. Journ. Geol. Soc., vol. xxxv, pl. x.

Genus: *Hoplonchus* Davis.

Sp. *H. elegans* Davis.

Small spine from the Halifax Hard Bed Coal Shale. It is curved and shows the usual ornamentation of smooth, well-spaced longitudinal ganoine-coated ridges. Denticles not shown.

Order: ACANTHODII.

Family: Acanthodidæ.

Genus: *Acanthodes* Agassiz.

Sp. *A. Wardi* Egerton.

Fin spine, scythe-shaped, much laterally compressed, with a groove and faint ridge parallel with the anterior margin disappearing distally. Distals flattened. Found in both districts. Pl. LXI., fig. 2.

Incertæ sedis.

Stemmatodus St. John and Worthen, 1875.

Sp. indet. They are clusters of denticles, and are probably dermal appendages of some extinct Shark. According to Prof. Anton Fritsch they are "gill rakers" of some shark.

SUB-CLASS: TELEOSTOMI.

Order: CROSSOPTERYGII.

Sub-order: Rhipidistia.

Family A.: Rhizodontidæ.

Genus I.: *Strepsodus.*

Sp. *S. sauroides* Binney.

Teeth showing the usual character, viz., laterally compressed and plicate at the base, but above this point the transverse section is nearly circular, relatively long and slender, apex sigmoidally bent, inner surface covered with well-spaced prominent fine striæ, external surface smooth. Pl. LXI., fig. 5.

Genus: *Rhizodopsis* (Huxley) Young, 1866.

Sp. *R. sauroides* Williamson sp.

Part of a body in a nodule in the shale above the Lower Foot Mine, Littleborough district; a mass of eroded scales shown. Other specimens of scales, vertebræ (?), teeth, &c., found. The scales are thin, elongated oval, obtusely pointed behind, the exposed area being rhomboidal and marked, when abraded, by concentric ridges crossed by fine radiating striæ. In some specimens in my collection from the Yorkshire Coal Measures this area is covered by a thin glittering layer of ganoine. Pl. LXI., fig. 11.

Family: Osteolepidæ.

Genus: *Megalichthys* Agassiz.

Sp. 1. *M. Hibberti* Agassiz.

This species is represented by scales, teeth, vertebræ, &c., and is found in both districts.

Sp. 2. *M. pygmæus* Traquair.

Some scales from the Lower Foot Mine I refer to this species. They are small, and the layer of ganoine is thick and *very* coarsely punctate.

Sub-order: Actinistia.

Family: Cœlacanthidæ.

Genus: *Cœlacanthus.*

Sp. 1. *C. elegans* Newberry.

Operculæ, jugular plates, scales from both districts, showing the characteristic ornamentation. Pl. LXI., fig. 12.

Sp. 2. *C. Phillipsi* Agassiz.

Caudal region of a large fish in a "Baum Pot" from the Halifax Hard Bed Coal. The Primary and Secondary caudal fins and also the anal (?) are shown.

Order: ACTINOPTERYGII.

Sub-order: Chondrostei.

Family: Palœoniscidæ.

Genus: *Elonichthys* Giebel, 1848.

Sp. 1. *E. Aitkeni* Traquair.

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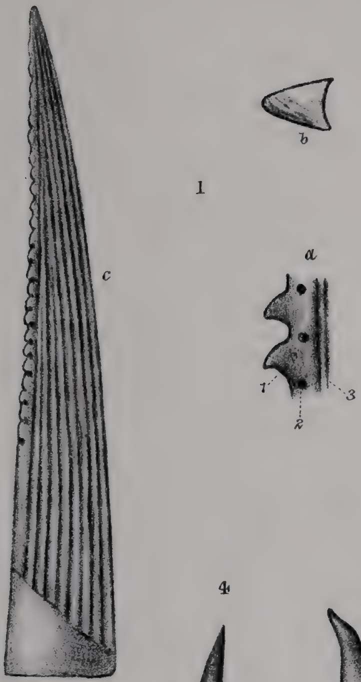

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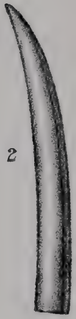

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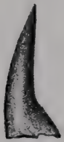

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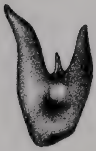

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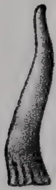

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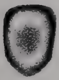

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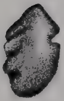

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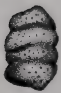

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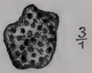

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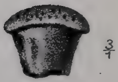

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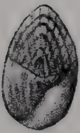

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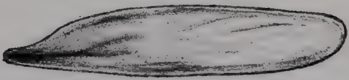

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Geo. West & Sons lith.

Detached scales ornamented with "strongly marked diagonal ridges which run nearly straight and parallel across the scale." Found in both districts, but rare. Pl. LXII., fig. 5.

Sp. 2. *E. semistriatus* Traquair.

Detached scales with the following ornamentation:—Anterior surface of scale is covered with well-marked "furrows and ridges which run backwards and downwards, some bifurcating or joining others and sometimes multiplied by intercalations. The posterior portion is occupied by numerous coarse punctures." Pl. LXII., fig. 4.

A fine Maxilla from the Lower Foot Mine I refer to this species. It is ornamented with "fine wavy, branching and anastomosing longitudinal ridges, the dentary margin being finely tuberculated." No teeth shown. This species is found in both districts, but is very rare.

Sp. 3. *E. Egertoni* (?) Agassiz.

Some detached scales show the ornamentation of this species, viz.:—"Well-defined ridges and furrows, the ridges being oblique. irregular, branching, intercalating, and ending at the posterior margin in acute serrations." On some scales one or two of the ridges run close to and parallel with the anterior and inferior margins. Very rare.

Sp. 4. *E. Binneyi* Traquair.

A small fish found in a nodule from the 40 yards' mine, Littleborough. The whole body to the commencement of the caudal fin, about two-thirds of the head much crushed, and also parts of Pectoral, Ventral, Anal, and Dorsal fins are shown. The length of the specimen is 8 cm., and the greatest depth of the body, at a point a short distance behind the head, is 30 mm.

Head is much crushed, and I am unable to identify any of the bones with the exception of one or two of the "branchiostegal rays."

Shoulder girdle, Supraclavicle, Clavicle and infraclavicle shown, the last two being crushed back and disarticulated from the former. The bones seem to be ornamented with well "spaced ridges which are more or less concentric with the margins."

Body. Scales. Those on the anterior part of the body are higher than broad, but behind the dorsal fin they become more equilateral. The anterior covered area seems very narrow, and the articular spine and fossa, on the under surface, are well marked.

Ornamentation.—On a *flank scale* it consists of "delicate wrinkles," a few of which run parallel with the anterior border, while behind this point they run across the scale in an anterior-posterior direction, with a tendency to converge into groups. Posterior border is denticulated. On the flank scales behind the dorsal fin the "wrinkles" run irregularly in a horizontal direction to the posterior denticulated margin.

On the *ventral scales* the ornamentation is peculiar. The centre of the scale is occupied by three or four "wrinkles" which converge behind but spread out fanlike in front. These scales are also much lower than those on the flank.

Lateral line is fairly well shown running from the centre of the posterior border of the supraclavicular, backwards towards the tail.

Fins: Pectoral.—The proximal two-thirds shown, but character of rays too imperfect for description.

Ventral.—Only root shown.

Anal.—Proximal part shown, the rays being delicate, distantly articulated, and ornamented with one or two longitudinal sulci.

Dorsal.—Imperfect, but character of the rays is well shown, the articulations being somewhat distant. The fin is placed opposite the interval between the anal and ventral fins. Pl. LXII., figs. 1 and 2.

This specimen is very similar to a cast (of the type specimen in the Woodwardian Museum) which was kindly shown to me by Dr. R. H. Traquair, F.R.S., &c.

Genus II.: *Rhadinichthys* Traquair, 1877.

Sp. *R. monensis* Egerton. Sp. 1850.

*Fragment of a small fish from the Lower Foot Mine,

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* I propose to deal more fully with this specimen in a separate paper.

Littleborough. The head and body to a point a short distance behind the ventral fin being shown.

Head.—Maxilla, mandible, and other bones shown.

Fins.—Pectoral and ventral shown.

Scales on the body well marked and show the following ornamentation:—"(*a*) A few delicate striæ parallel to the anterior and inferior margins, and (*b*) four or five ridges commencing at the posterior denticulation and running forwards on the scale for some distance more or less parallel with the superior and inferior borders."

Besides above I have found many detached scales in both districts. Pl. LXII., fig. 3.

Genus III.: *Acrolepis* Agassiz.

Sp. *A. Hopkinsi* McCoy.

A large and fine specimen of this fish was found by the late Mr. James Spencer, of Halifax, in a "Baum Pot" in the shale above the Halifax Hard Bed Coal, at Elland, near Halifax. The head, parts of the body, and some traces of the fins are shown. The specimen is now in the "Davis Collection" at the British Museum.

There is part of the body of a fish—showing the scale ornamentation very well marked—in the "Lister Collection," belonging to the Borough of Brighouse, also from the same shale.

Besides the above, I have a "tail pedicle" from the Lower Foot Mine, Littleborough, and detached scales from the Halifax district showing the characteristic scale ornamentation, viz., "prominent oblique ridges, with occasional branching and intercalation on the flank scales"; on the caudal scales the ridges sometimes fuse to form a reticulation at the anterior-inferior and posterior-superior angles. Pl. LXII., fig. 6.

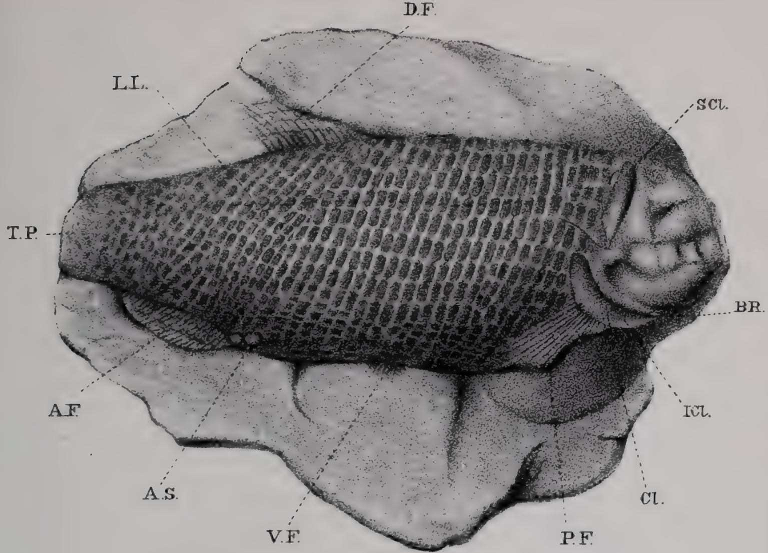
Family II.: Platysomidæ.

Genus: *Platysomus* Agassiz.

Sp. *P. parvulus* Agassiz.

Detached head-bones (maxilla, &c.) and scales. The scale ornamentation being "very fine, parallel vertical striæ." Pl. LXII., fig. 7.

Before concluding this paper, I must acknowledge, with warmest thanks, the great obligation I am under to Dr. R. H. Traquair, F.R.S., &c., and Mr. A. Smith Woodward, F.G.S., &c., for great and kindly help in the past: also to Mr. Magson, of Hollingworth, near Littleborough, for loan of specimens, &c., and to Mr. John Butterworth, F.R.M.S., for the "correlation of the coal seams" of the two districts.



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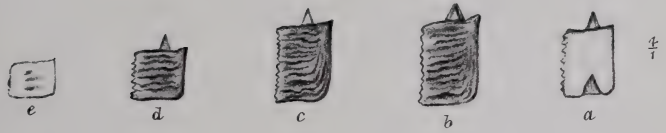

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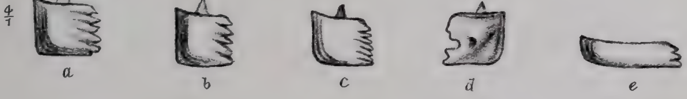

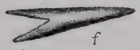

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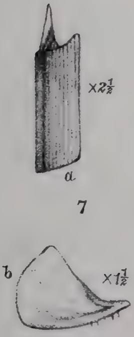

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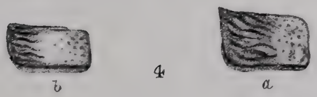

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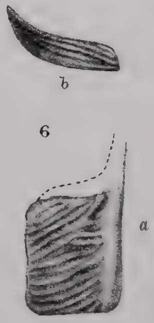

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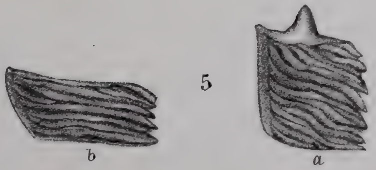

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Edgar D. Wellburn del.

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TABULAR SUMMARY OF THE FISH-REMAINS, SHOWING THEIR STRATIGRAPHICAL DISTRIBUTION.

	HALIFAX MEASURES.			LITTLEBOROUGH MEASURES.		
	Soft Bed Coal Shale.	Hard Bed Coal Shale.	36 Yards Band Shale.	Lower Foot Mine Shale.	Upper Foot Mine Shale.	40 Yards Mine Shale.
1. *Pleuracanthus cylindricus* Ag.				*		
2. *Diplodus gibbosus* Ag.		(*)		*		
3. *Callopristodus pectinatus Ag.* sp.				*		
4. *Janassa (linguæformis?)* Atthey		(*)				
5. *Helodus* sp.?		(*)				
6. *Pleuroplax rankinei* Handcock & Atthey		(?)		*		
7. *Pleuroplax attheyi* W. J. Barkas		*				
8. *Sphenacanthus* sp. new?				*		
9. *Hoplonchus elegans* Davis		*				
10. *Stemmatodus* S. J. & Worthen				*		
11. *Acanthodes wardi* Eg.	(*)	*		*		
12. *Strepsodus sauroides* Bin.		*		?		
13. *Rhizodopsis* ,, Wn.		(*)		*		
14. *Megalichthys hibberti* Ag.	(*)	*	(*)	*	*	
15. ,, *pygmæus* Tr.				*		
16. *Cœlacanthus elegans* Newb.	(*)	*		*		
17. ,, *phillipsi* Ag.		*				
18. *Elonichthys aitkeni* Tr.	(*)	*		*	*	
19. ,, *semistriatus* Tr.		(*)		*		
20. ,, *binneyi* Tr.						*
21. ,, *egertoni* Ag.		(?)		*		
22. *Rhadinichthys monensis* Eg.	(*)	(*)		*	*	
23. *Acrolepis hopkinsi* McCoy		(*)		*		
24. *Platysomus parvulus* Ag.	(*)			*		

NOTE.—Fish-remains are exceedingly rare in both districts, and a great many of my journeys to the district have not yielded a single specimen. As far as I know, this is the first time the "Fish Fauna" of the Littleborough district has been placed on record.

Those marked thus (*) are new to the Halifax Measures.

EXPLANATION OF PLATES.

PLATE LXI.

Fig. 1. *Sphenacanthus* sp. new? *a*—Magnified view of: 1. Primary denticles on posterior border. 2. Secondary denticles between last and most posterior ridge. 3. *b*—Transverse section at *c*.

Fig. 2. *Acanthodes wardi* Eg. Fin Spine of.

Fig. 3. *Diplodus gibbosus* Ag. Tooth of.

Fig. 4. *Megalichthys hibberti* Ag. ,,

Fig. 5. *Strepsodus sauroides* Bin. ,,

Fig. 6. *Janassa.* Tooth of.

Fig. 7. *Pleuroplax rankinei* Agassiz. Tooth of.

Fig. 8. ,, *attheyi* W. J. Barkas. ,,

Fig. 9. }
Fig. 10. } *Helodus* sp.? Tooth of.

Fig. 11. *Rhizodopsis sauroides* Williamson. Scale of.

Fig. 12. *Cœlacanthus elegans* Newberry. Jugular plate of. Inner surface.

PLATE LXII.

Fig. 1. *Elonichthys binneyi* Traquair. Br.—Branchiostegal rays. Cl.—Clavicle. Icl.—Infraclavicular. Scl.—Supraclavicular. L.L.—Lateral line. D.F.—Dorsal. P.F.—Pectoral. V.F.—Ventral. A.F.—Anal fins. A.S.—Anal Scales. T.P.—Tail pedicle.

Fig. 2. *Elonichthys binneyi* Traquair. Scales of. *a*—Under surface. *b*—Anterior flank. *c*—Posterior flank. *d*—Caudal; and *e*—Ventral scales enlarged.

Fig. 3. *Rhadinichthys monensis* Egerton sp. Scales of, from: *a*—Neck. *b*—Anterior flank. *c*—Posterior flank. *d*—Lateral line. *e*—Ventral; and *f*—Ridge scales enlarged.

Fig. 4. *Elonichthys semistriatus* Traquair. Posterior flank scales enlarged. *b*—From a more ventral position than *b*.

Fig. 5. *Elonichthys aitkeni* Traquair. *a*—Flank. *b*—Ventral scales enlarged.

Fig. 6. *Acrolepis hopkinsi* McCoy. *a*—Flank. *b*—Ventral scales enlarged.

Fig. 7. *Platysomus parvulus* Agassiz. *a*—Flank scale. *b*—Maxilla, both enlarged.

NOTES ON THE CAVES OF YORKSHIRE. PART II. BY S. W. CUTTRISS.

(*Read November 17th*, 1898.)

PLATES LXIII.-LXV.

In my previous communication on this subject, which appears in the Proceedings of your Society for last year, it was found convenient to divide the area under consideration into three Sections: 1st, the Yoredales, including the rocks of that formation; 2nd, the Southern Carboniferous or Craven Section, including the Carboniferous Limestone lying between the Upper and Middle Craven Faults: 3rd, the Main Carboniferous Section, comprising the remainder of the Carboniferous Limestone outcrop included within the imaginary boundary therein defined. (Proc. Yorks. Geol. and Polytec. Soc., vol. xiii, p. 313.)

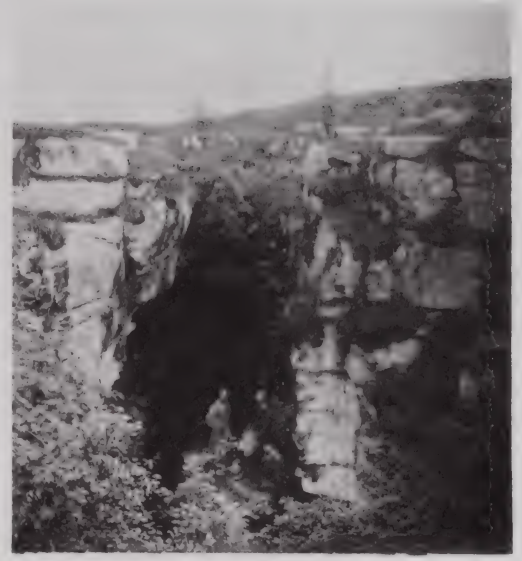
As a field for studying the action of water on limestone, and the effect of the resulting underground watercourses on the general drainage of the district, the third Section is by far the most interesting, and it is to this Section the present notes refer. The district includes the whole of the Carboniferous Limestone contained within a boundary roughly determined by the Leck Fells, Kingsdale, Chapel-le-dale, and Ribblesdale, its southern extension being limited by the North Craven Fault. The Memoir of the Geological Survey of the District refers to this limestone as follows:—"The Great Scar Limestone attains its highest point above the sea (about 1,500 feet) on the S.W. side of Ingleborough, near Newby Moss; it falls to about 1,200 feet at Southerscales Fell and South House Moor in a distance of nearly three miles, which equals a fall of 100 feet per mile, or 1 in 53 nearly, not much more than a dip of 1° on the average, but in places of course the dip becomes steeper. The base of the Carboniferous Series lies at an elevation of 725 feet at God's Bridge and Thornton Force, nor in Chapel-le-dale does it anywhere rise more than 150 feet above this, but in

Ribblesdale and Crummack it is more variable in height . . . the Great Scar Limestone must be as much as 600 feet thick on the average." In the exposed parts of the outcrop where the pot-holes are generally found, the actual thickness of the limestone does not exceed about 500 feet, as the present surface is considerably below that of the true top, owing to atmospheric denudation.

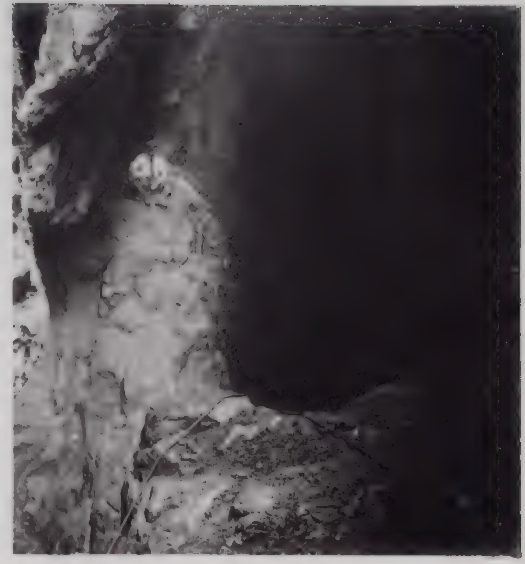
This limestone plateau has been cut into deeply by the Kingsdale, Chapel-le-dale, and Ribblesdale valleys, the lower parts of which have penetrated into the underlying Silurian Strata. The first two valleys are bounded by precipitous cliffs which rise in a "bold series of scars to the surface of the limestone." These scars are not so noticeable in Ribblesdale, the valley being much wider, having gentler slopes, and to a considerable extent the rock is buried under a great thickness of Drift, which lies in the upper part of the valley and on the hill sides to an elevation of over 1,500 feet.

In several places the surface of the limestone spreads out in wide, bare, plateaus or terraces (locally called Helks), particularly around Ingleborough and the south side of Whernside. These terraces are fantastically weathered along the numerous lines of fissure, which form a complete network all over the surface. In other parts the rock has been covered with a considerable thickness of Drift, in which are innumerable conical depressions known as Sinks or Swallow Holes, the loose material having been carried away by the water as it sinks into the fissures of the rock. One of the largest of these is Braithwaite Wife Hole on the Chapel-le-dale side of Ingleborough. It is 170 yards round on the surface, and shows a section of Glacial Drift (clay and gravel) to a depth of about 20 feet and about 40 feet of limestone below (Geological Memoir, p. 35). A very symetrical sink, 114 yards round, is situated near Gable Pot on Leck Fells, in the bottom of which grows a single ash tree about 50 feet high, the top of the tree just appearing above the surface.

The contrast between the caves of Sections II. and III. is very marked. In the former there is not a known accessible



ROWTEN POT, KINGSDALE.



THE "BRIDGE," ROWTEN POT. THE WATER GULLEY ON THE LEFT AND THE MAIN CHASM ON THE RIGHT.

ROWTEN POT, KINGSDALE.

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII., Plate LXIII.

NATURAL HISTORY

cave which has a stream of water flowing through it, and they are all more or less choked up with drift and other deposit. In the latter section the reverse is the case, the writer not being aware of a single example which is not at present an active drainage channel.* Some have dry passages, resulting from the water finding a lower level, but all in some part of their ramifications have water flowing through them. Another distinction is the abundance of pot-holes in the one and entire absence of similar phenomena in the other (No. II.). The usual acceptation of the word Cave implies a more or less horizontal passage or passages in which may be larger openings designated caverns. The term Pot-hole is applied to vertical shafts or chasms in the limestone, which are enlarged fissures in the rock due to the action of falling water. No hard and fast line can be drawn between the two classes of phenomena, as frequently both kinds are associated in one drainage system. Pot-holes frequently have caverns at the bottom, while the caves occasionally include pot-holes in some part of their course.

The caves may be classified under the two heads of Caves of Engulphment and Caves of Débouchure. In the Leck Fell and Kingsdale districts they are entirely of the first-named variety, if we except the Witches Cave in Easegill, while in Chapel-le-dale and Ribblesdale the principal ones are Caves of Débouchure. Caves of Engulphment—those which receive water —are usually low and encumbered with loose stones, entrance being only possible in many cases by creeping. The passage generally increases in height to 20 feet or more, but rarely exceeds 6 feet in width, being more often under 3 feet. When it does expand sufficiently to be dignified by the title of a chamber or cavern, either a present or past waterfall is always associated with it. The upper part of the walls is generally covered with a soft calcareous deposit, and occasionally small stalactitic ribs, but as a rule these caves contain few stalactites of any size, and what there are are usually very impure. Some of the caves may be traversed for a quarter of a mile or more, but they generally terminate, as far as it is possible to explore them, in one of three ways. Firstly, a deep pool with smooth vertical walls converging to a fissure only a few inches wide, the water showing no perceptible flow, and more or less covered with scum. Secondly, if the passage is in the direction of the dip of the rock it will broaden out and the flat roof descend to the surface of the water, or meet the loose stones which choke the channel. Faulting may, no doubt, in some cases be responsible for these obstructions: in other cases they occur when the channel passes from one bed of rock to a lower. In this latter case, if an opening can be cleared sufficiently large to squeeze through, the channel will open out again and may form a Cave of Débouchure. The third manner in which these caves terminate is by ending abruptly in the side of a Pot-hole. Great care should be observed in exploring Caves of Engulphment, owing to the possibility of a sudden rush of water and the danger of falling down holes which are easily unobserved in the darkness; for this reason the leader of the party should always be roped.

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* If any dry caves exist they will probably be found in the neighbourhood of Crummack Dale and the Moughton Fells, which is the most likely quarter to search for caves containing bone deposits.

Caves of Débouchure far exceed the others in number. The entrance, with few exceptions, is either at the base of a limestone scar or at the upper end of a narrow gorge. It is generally commodious, with a broad flat roof, forming the underside of a bed of rock. A thin parting of softer material separates this from the underlying rock in which the water channel is cut. The softer rock is frequently eaten away for some distance on both sides of the channel, leaving the roof unsupported over a large area. In the caves on the east side of Ribblesdale the entrance passage rapidly shallows and creeping becomes necessary. This inconvenient attitude is not, however, necessary for long, as a vertical cross fissure will usually be reached, 20 feet or more in height. A cascade or waterfall will then have to be negotiated, beyond which the passage becomes a simple water-worn channel, gradually shallowing and broadening until it becomes too low to permit of further progress. An exception is found in

High Birkwith Cave, which terminates in a deep pool, the roof apparently dipping under the surface at the far end. In the notes made at the time of visit I do not find any suggestion as to the cause of this pool being formed. There may be a stalagmitic dam holding back the water, and if the pool was drained it might be possible to penetrate further. Brow Gill Cave, which receives the water from Calf Hole, a quarter of a mile away, can be explored with less discomfort than most of the others. It affords a variety of experiences and mild excitements, and about 150 yards from the entrance a waterfall 30 feet high is reached. Although the fall itself cannot be climbed, a fairly easy way up the rocks may be found, and by crawling along an old channel the top of the fall can be reached and the passage beyond explored for some distance, until progress is barred in the usual manner by the lowering of the roof. It is almost invariably the case that where a waterfall occurs an old channel will be found which affords a means of passing the obstacle.

In channels at or near the top of a bed of rock, the limestone is cut into long thin vertical ribs, the edges of which are frequently as sharp as knives. Examples of this description of erosion may be seen in Brow Gill Cave, also Douk Cave, in Chapel-le-dale, but it occurs to a greater or less extent in most caves. When the passages are cut through a series of thin strata, such as exist at the top of the main mass of limestone, these stand out in horizontal slabs with keen edges similar to the vertical ribs.

The writer only knows at present of three caves in the whole district in which it is possible to complete the journey from daylight to daylight, viz.:—Short Drop Cave on Leck Fells, which empties into Gable Pot; Rowten and Jingling Caves, Kingsdale, which unite and terminate in Rowten Pot; and Long Churn, communicating with Alum Pot in Ribblesdale. It will be noticed these all terminate in pot-holes. It might be possible, with the expenditure of considerable time and labour, not unattended with danger, to force a way through from Far Douk into Douk Cave (Chapel-le-dale), and from Calf Hole to Brow

Gill Cave; but the latter is the only one of the five named in which it would be possible to follow the water from its engulphment to where it finally emerges into the open.

Although the caves afford interesting work to the explorer, far greater interest is attached to the pot-holes which abound in the district. They afford considerable sport to the climber who wishes to penetrate their depths, a sport accentuated by the element of mystery and awe surrounding them. Many attain depths of 300 feet and over, and it is here the pluck and endurance of the explorer are called into full exercise, especially when the diffiulties are increased by falling water and the ever present danger of falling stones.

Pot-holes are always found at or near the top of the Carboniferous Limestone, and only in such localities where there is higher ground to give birth to the streams which are the active agents in their formation. The appearance of these chasms on the surface varies considerably, the size of the opening being no criterion of their depth. Gable Pot on Leck Fells is 450 yards in circumference, being the largest in area of any in the country. yet its extreme depth does not exceed 115 feet. In contrast to this is Bull Pot, Kingsdale, the opening of which is so small it has been covered over with slabs of rock from the hill side. This was first completely explored by Messrs. W. Parsons, J. W. Swithenbank, and the writer on May 28th. 1898, its depth being found to be 220 feet. Also Long Kin West, on the south side of Ingleborough, a narrow fissure the top of which may be stridden across, is stated by Mr. E. Calvert to be about 325 feet deep. Mr. Calvert was the first to complete its descent, although several attempts had previously been made. Of the better known pot-holes, Alum or Helln Pot, on the Ingleborough side of Ribblesdale, appears to have received considerable attention from the earlier explorers, its extreme depth being given by Prof. Boyd Dawkins at about 300 feet. A full description of this awesome abyss is given in Boyd Dawkins' "Cave Hunting."

Probably no cave has received more attention, or formed the subject of communications to Scientific Societies more frequently, than Clapham Cave, partly on its own account and also because it is believed to have been the outlet for the water falling into Gaping Ghyll Hole on the moorland above. Efforts have repeatedly been made to discover a communication between the two, notably within the last few years by Mr. Calvert, but as yet without success. Gaping Ghyll Hole itself remained an unfathomable mystery until 1895, when Mons. E. A. Martel, of Paris, successfully completed its descent and discovered an immense cavern at the bottom having an area of about half an acre, and which he places sixth in the list of known caverns in the world. The descent was made by the aid of rope ladders to the great depth of 350 feet.*

In the following year (1896), Mr. E. Calvert and several friends, among whom I had the good fortune to be included, made several descents and discovered numerous passages and other caverns, besides completing a careful survey of the main cavern itself. Mr. Calvert devised a scheme whereby the explorers were lowered to the bottom by a rope attached to a windlass, obviously a safer and more expeditious method than Martel's, while it had the additional advantage of enabling several people to be at the bottom at one time to continue the explorations. In justice to Mr. Calvert it should be mentioned his preparations were actually in progress when Mons. Martel forestalled him, neither gentleman being aware of the other's intentions.

Although Gaping Ghyll is undoubtedly the finest pot-hole in the country, it must give place to Rowten Pot, in Kingsdale, for pre-eminence in the matter of depth. Separating Whernside from Gragareth, Kingsdale, though perhaps the most lonely and dreary valley in all Yorkshire, is of considerable interest to the geologist and cave-hunter. The Kingsdale Beck sinks underground at its head, appearing on the surface again two miles lower down at Keld Head. On the east side of the valley there is an entire absence of surface water, and although several streams descend from the slopes of Gragareth on the west, all of them sink underground as soon as they reach the limestone, and presumably swell the waters at Keld Head. Rowten Pot is situated exactly opposite the farmstead of Braida Garth, at an elevation of 1,192 feet. It receives the waters from Rowten Gill and Jingling Gill, which unite underground and fall into the chasm 30 feet below the surface. These channels, which may be followed throughout, if one does not object to crawling occasionally in the water, furnish a good example of the erratic course often followed by underground streams, twisting about in most unexpected directions. The opening of the chasm, which is unprotected by wall or fence, measures 75 feet by 50 feet. Close to the south end is a smaller opening, 16 feet by 5 feet, down which a stone may be dropped 235 feet before it touches the bottom of the main shaft.

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* Irlande et Cavernes Anglaises. E. A. Martel, 1897, pp. 335-364.

During the last 35 years repeated attempts have been made to explore this pot-hole by different people, but all failed in reaching the bottom, or even ascertaining its extreme depth, resulting in most exaggerated reports as to its supposed extent.*

In the autumn of 1896 several friends and myself turned our attention to this chasm, but owing to the quantity of water present, a descent of more than 150 feet could not then be accomplished. Three times during the following spring we returned to the attack, and a depth of 315 feet was attained. The evil genius of the place was, however, determined to defend the secret of Rowten Pot to the last, and we had to come away crestfallen, but more resolved than ever to fathom the mystery. Our greatest enemy was water, and considerable caution had to be exercised on that account, as a sudden rush might have been attended with serious consequences.

On the evening of July 4th, 1897, five members of the Yorkshire Ramblers' Club and two men, Harry Woodhouse and Tom Somers, engaged as assistants, might have been seen toiling

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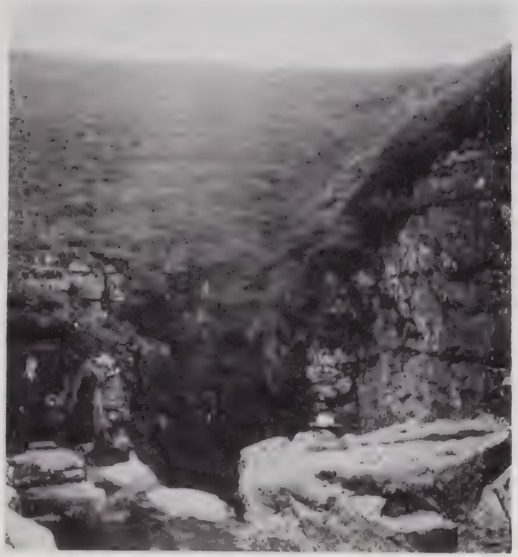
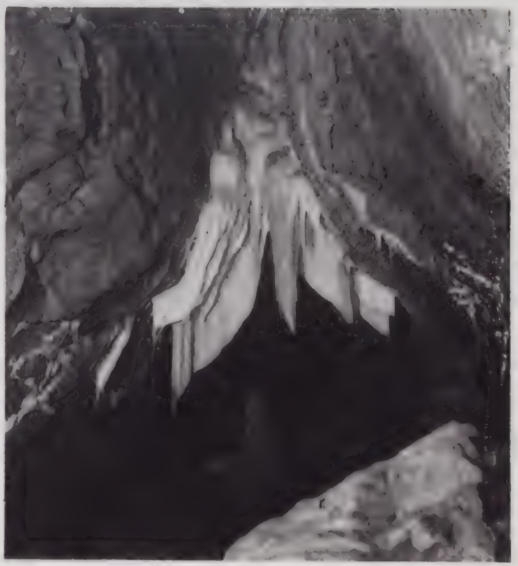
* The Craven and North-West Yorkshire Highlands, H. Speight, pp. 260-261.

Ingleton, Bygone and Present, R. R. Balderston, pp. 61-3.



GAPING GHYLL HOLE.



STALACTITE CURTAIN, GAPING GHYLL CAVERN.

GAPING GHYLL, INGLEBOROUGH.

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII., Plate LXIV.

up the mountain side, struggling with a large quantity of tackle, for another attempt on the pot-hole. This was no easy task, the goods weighing about 3 cwt., consisting of some 200 feet of rope-ladders, 1,700 feet of strong ropes, two large flare-lamps, with a quantity of paraffin, two complete sets of telephone apparatus, various pulley-blocks, tools, candles, and a miscellaneous assortment of other necessary articles. At six o'clock next morning we were at the mouth of the chasm, and the descent commenced. The first 70 feet present no special difficulties, and can be climbed without the aid of a rope. Here the first ladder was fixed to facilitate the descent to a ledge named the Bridge Platform, about 100 feet from the surface, where a natural arch of rock spans the water gulley. To this platform all the tackle had to be lowered, as it formed the main working level. Daylight not penetrating further, one of the large flare-lamps was let down still further into the hole. The rope-ladders were now lowered and made fast on the Bridge, and Messrs. T. Booth, W. Parsons, J. W. Swithenbank, and myself in turn climbed down, through two waterfalls, to the bottom of the main chasm, 235 feet from the surface. Mr. C. Scriven, who was in charge of the work on the Bridge, then lowered the ladders bodily to where we were, and three of the party continued the descent, while I remained to maintain communication with those above by means of the telephone, and do other necessary work. The task of waiting for several hours, alone and wet to the skin, was not an agreeable one, and I was glad when, about eleven o'clock, Parsons returned with the good news that the bottom had been reached and Rowten Pot conquered at last. It was now my turn to go forward, and after negotiating two more waterfalls and three ladder climbs, followed by a descent down a tortuous passage, I stood at last on the very bottom, 365 feet below the surface, and more than 20 feet below the bottom of the valley itself at that point. The lowest portion consists of a series of short passages, having several feet of water in them, and paved with well-worn stones. From the clean, waterworn appearance of the rocks and the small size of the passages, they must rapidly and frequently fill with water; we did not, therefore, linger in such an undesirable locality longer than necessary to make some instrumental observations and leave a record of our descent.* The temperature of the water was found to be 48° F., that of the air $48\frac{1}{2}$° F., while the outside temperature was about 65° F.

On returning to the bottom of the main chasm, considerable time was lost in re-establishing communication with those above owing to the failure of the telephone. In our tired and wet condition the ascent of the 135 feet of rope-ladder without a rest was very trying, but all reached the Bridge again without mishap. Then followed the work of hauling everything up the remaining 100 feet to the surface. Only those who have had experience in hauling ropes under such trying conditions can fully appreciate our obligations to Mr. Scriven and the others for the generous way in which they laboured on the Bridge. The whole expedition occupied over 14 hours of continuous work.

The writer is frequently asked if there is no danger to be apprehended from the presence of impure air in these chasms. A not inconsiderable experience in caves and pot-holes, the latter both absolutely dry as well as wet, leads me to affirm there is no danger to be feared on that account, under usual conditions, in limestone formations. I have never felt the slightest inconvenience from that cause, or has the light of the candle shown any diminution in intensity. With the object of ascertaining the proportion of the constituents of the air, a sample at a depth of about 300 feet was obtained during one of the attempts on Rowten Pot, together with one from the surface for comparison. These were submitted to Prof. Smithells, who kindly consented to have them analysed at the Yorkshire College, but, unfortunately, the quantity supplied was too small to allow of accurate determination of the carbon dioxide; the relative proportion of oxygen was,

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* The ribbed character of erosion of the rock referred to in the earlier part of the paper is here found in profusion, and with the additional peculiarity that a large proportion of the ribs or flakes are supported from above instead of below. This latter is a feature not noticeable in other pot-holes to any extent.

ROWTEN POT. *KINGSDALE.*

APPROXIMATE SCALE. 1 INCH = 30 FEET.

S. W. CUTTRISS. 1897

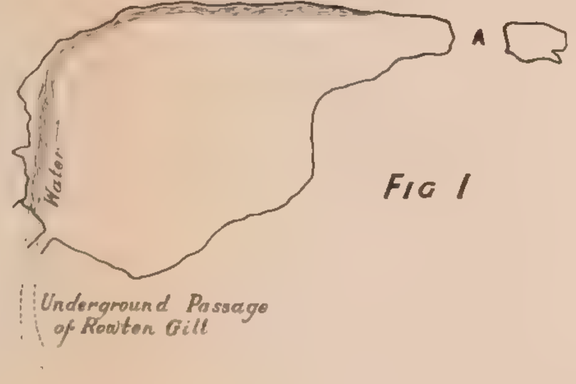


FIG 1

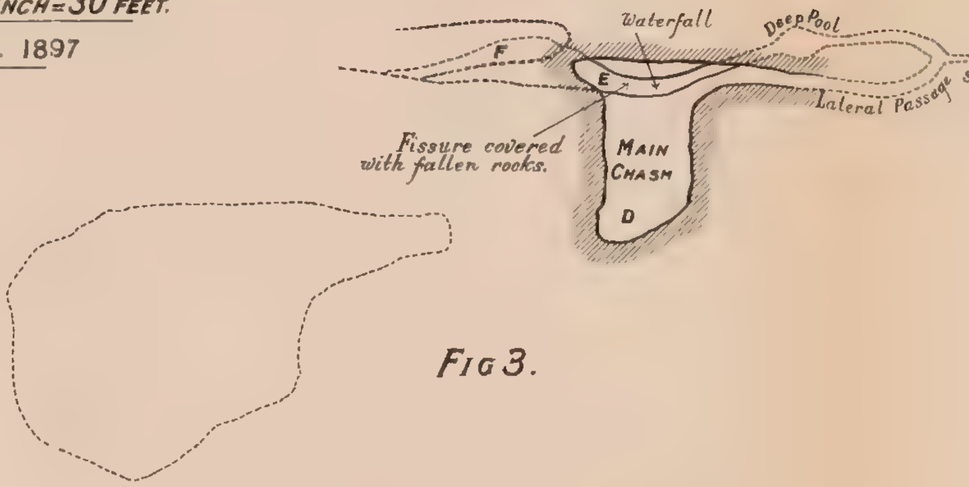


FIG 3.

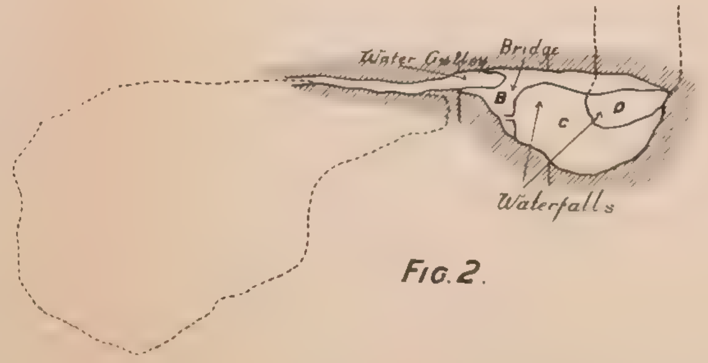


FIG. 2.

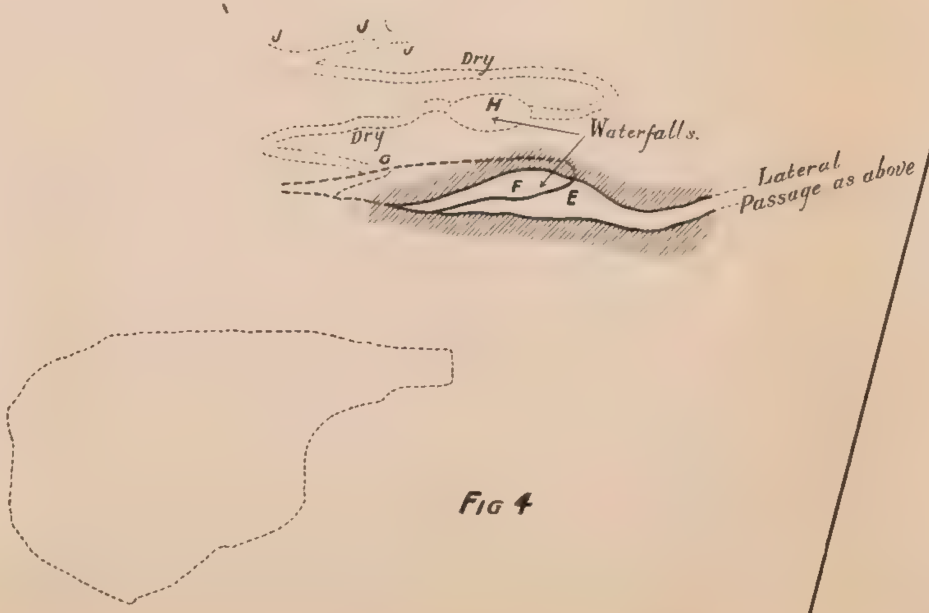
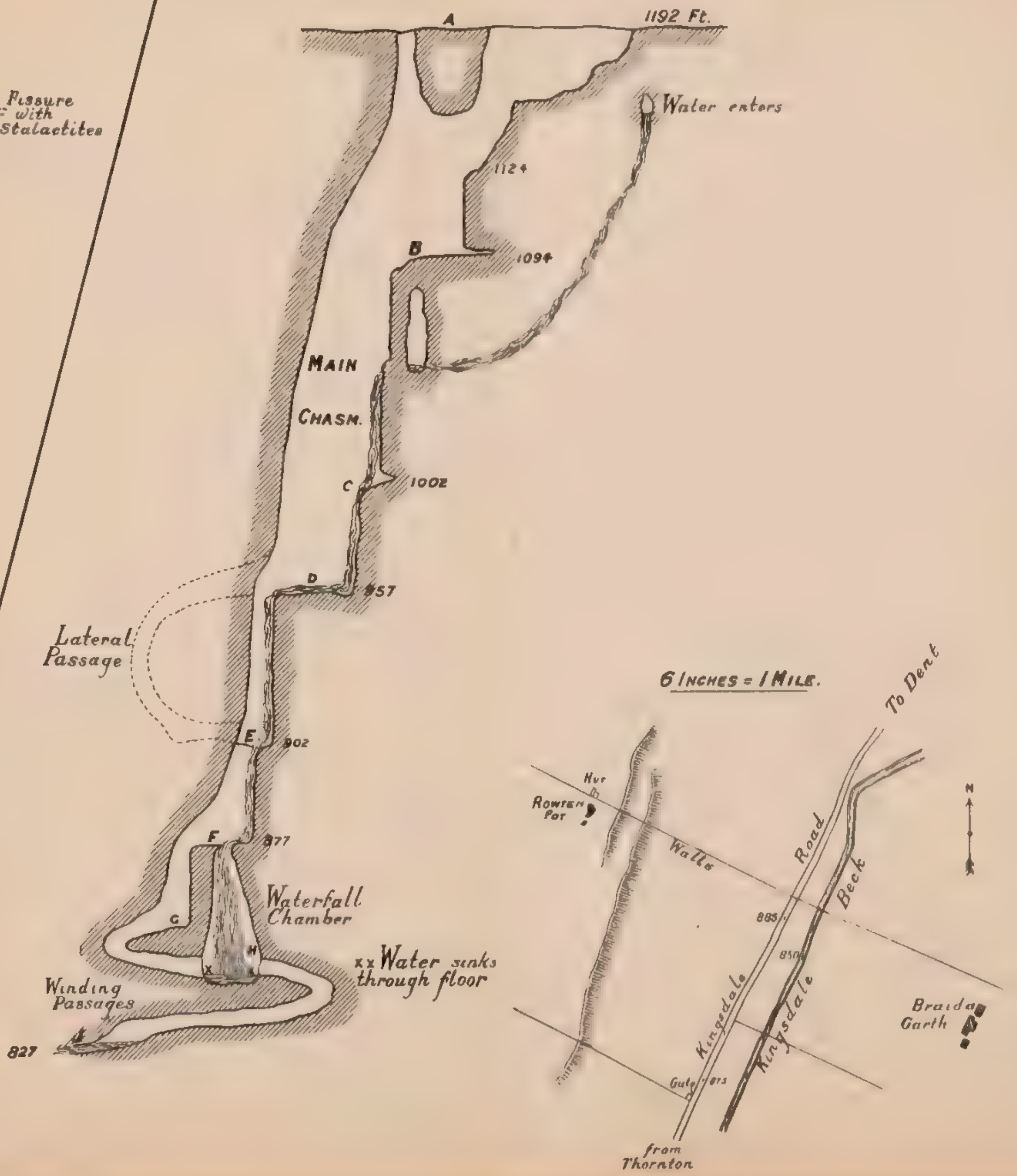


FIG 4

DIAGRAMMATIC SECTION.



therefore, merely determined. The results showed a slight deficiency of oxygen in the air from below, but the difference was not very large.

Referring to the diagrams, these must not be accepted as absolutely correct, but merely as sketch plans, drawn partly from memory and notes, with a few dimensions taken at the time. Owing to the difficulty of the descent there was no opportunity to make careful surveys, neither were the mental faculties in a condition to undertake such work. Fig. 1 shows the surface outline of the opening, and figs. 2, 3, 4, are plans at various levels, the relative positions of the surface opening being shown in dotted lines. The vertical section in particular is merely intended to represent the various levels, as, owing to the tortuous character of the fissures, a true section is impossible.

ON RECENT PRE-HISTORIC "FINDS" IN THE NEIGHBOURHOOD OF TODMORDEN, YORKSHIRE.

BY ROBERT LAW, F.G.S.

(*Read November 17th*, 1898.)

PLATE LXVI.

On Thursday, July 7th of this year (1898), a very interesting and important archæological discovery was made on a portion of land known as Higher Cross Stone Farm, belonging to Mr. Sutcliffe, of Todmorden. In a field on this farm, called Black Heath, a ring circle, made of earth, has long been known to exist, and has gone by the name of the "Frying Pan." No history or tradition exists as to the origin of this circle, and various speculations have from time to time been indulged in by the residents. Some have called it a Roman Camp, others a fairy circle, others a circus ring, made to break in horses; but the excavations prove it to be a burial place of pre-historic times. Mr. Tattersall Wilkinson, of Burnley, a well-known archæologist of considerable experience on ring circles, along with the writer of this article, came to the conclusion, on hearing of this circle, that it probably contained human remains, and an excavating party was organised to meet on the spot on the day above mentioned. This party met at the appointed time, and the plan of operations was to find the centre of the circle, by means of a tape, then to dig a circular trench, about three feet from the centre, in which space it was thought the remains would lie. The ring was nearly a perfect circle. It was raised conspicuously above the ground. The rim of raised earth was about three feet wide, and the diameter of the whole circle was thirty yards. After the digging had been going on for a short time, burnt soil and charcoal were met with, and the top of an urn was exposed to view. The diggers then went to work with the greatest possible care, and very soon a beautiful urn was laid bare exactly in the centre of the ring. The urn was embedded in charcoal and calcined bones. It was ten inches high and nine inches at the top, tapering to about three inches wide at the bottom. There was a rim or collar in the upper part of the urn about three inches deep, which stood out about one inch in relief from the lower part of it. The collar was ornamented, probably by a pointed stick, with the herring-bone pattern. The outer part of the urn was plain. In clearing away the débris from the urn another one was discovered, different in pattern and less in size, but in a very perfect state of preservation.

About two feet from this, on the opposite side of the central urn, another urn was discovered and laid bare, by carefully digging round it with a trowel. This urn was also in a good state of preservation, and about the size of the second one, but differently ornamented. These smaller urns were the same shape as the larger central one, but the ornamentations were not so fine, and they were made of inferior clay. On the south side of the circle, about two feet from the centre, another urn was discovered, but it appeared to be insufficiently baked when manufactured, and had decomposed and crumbled into dust. From the inside of this urn a large quantity of calcined human bones and charcoal was dug up, but the bones were very fragmentary, and the sex of the person to whom the bones belonged could not be determined. Several portions of cranium, rib bones, and lower and upper leg bones were found among the débris.

Within a few inches of this urn two small (so called) incense cups were found. One of them was very perfect and in an excellent state of preservation, and was beautifully ornamented all over. These cups were about three inches in height and three and a half inches in diameter, but tapered a little at the bottom. Indications of three other urns were observed, but they were so much decomposed that little or nothing could be made of them. The others seemed to be arranged about the large central urn and about two feet apart. When the earth had been cleared away from the three perfect urns, and before they had been removed, several photographs were taken of them *in situ*. One of the smaller urns leaned a little to the south. Several pieces of flint and chert were dug out of the excavation. The urns and incense cups being removed were put into baskets and conveyed to Todmorden, where they were re-photographed and placed in the Free Library for their safe keeping.

On July 13th, six days after the "find," the urns were opened at the Co-operative Hall, Todmorden, before a very large gathering of scientific ladies and gentlemen drawn from the surrounding districts. Mr. Tattersall Wilkinson, Dr. Crump, of Burnley, and the author were entrusted with the opening of the urns.

The largest one, which was of superior make to the others, was the first to be operated upon. The work was tedious and was done in the most careful way possible. Each operator commenced to pick out by means of a small pocket knife the substances deposited in the urns, and the material was closely examined as it fell out on the table. For the first half hour or so nothing particular was found. The contents which had been so far dug out were portions of broken urns of a similar pattern to the urn that was being examined, but were not portions of it, and must have been placed there as filling-in material. Along with these urn fragments there was some dark brown sand, which appeared to have been burnt, quantities of bituminous soil, small fragments of bones, and bits of charcoal. As the examining party dug deeper into the urn human bones became more numerous and in larger fragments and of a more determinable character, and this went on until the urn had been half emptied. The rest of the contents of the urn then showed signs of being almost entirely calcined bones, and bone

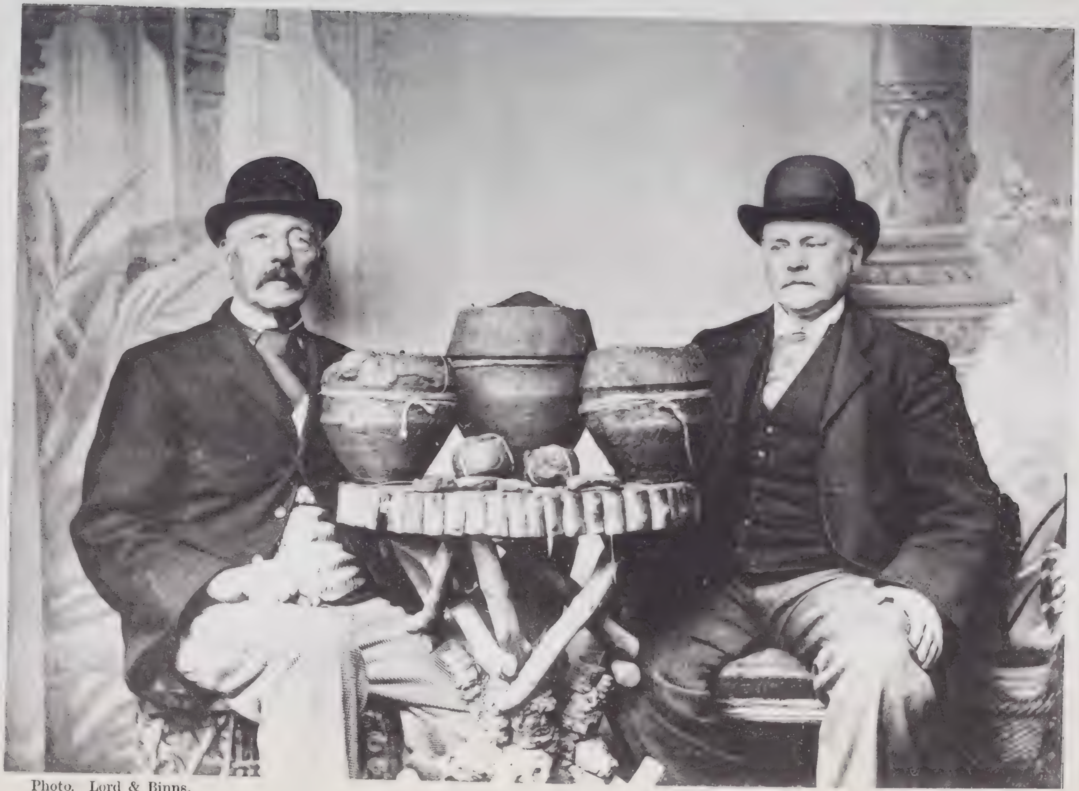


Photo. Lord & Binns. Todmorden.

URNS FOUND AT HIGH CROSS STONE FARM, TODMORDEN.

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII., Plate LXVI.

CENTRAL PARK
NEW YORK
NATURAL HISTORY

after bone was picked out, examined, and laid on the table. Among these bones were fragments of various sizes, of cranium, portions of scapula, pelvic bones, femur, tibia and other bones of the legs. Besides these there were fragments of ribs and perfect toe bones.

Presently a small cup was laid bare inside the urn, and a few pokes with the knife so far emptied it of its contents that an ancient relic could be seen which differed from any that had yet been found. A moment later a piece of metal was picked out of the cup resembling a spear head. It was about 2½ inches long and 1¼ inches wide at one end, and tapered to a point at the other. It was thin and flat and sharp at the sides and point. It contained a rivet at the two extremities and another one about half way up one side. A bronze pin was also found about the same time as this piece of metal, and on careful examination the metal and the pin were made out to be a bronze brooch, the pin having probably been detached in extracting it from the bones in the cup. Besides this brooch about a dozen beads of a necklace were found, which were chiefly of a rounded shape and about half an inch in diameter. Some of the beads seem to have been made of jet, and some of bone, and were more or less rudely carved. A bone pin was next brought to light. It was about two inches in length and the eighth of an inch in diameter at one end, tapering towards a point at the other. It was cylindrical in form and slightly curved. The fact of all these ornaments having been carefully placed in the cup and buried with the urn points to the cup having been used as a utensil in which to preserve what was considered of great value. Several human teeth were also found in this cup.

The opening of the two inferior urns proved that they contained nothing more than the sweepings up of the funeral pile which probably took place after the calcined bones had been placed in the more important urn.

Since this discovery was made a beautifully-formed flint arrow head of the leaf-shaped pattern has been found in the same hole from which the urns were dug. There have also been two or three more urns discovered within the same circle, but their contents have not yet been disclosed. The finding of the rude bronze brooch and bone pin within one of the urns, and the associated flints, prove beyond a doubt that the interment was made in pre-historic times, and that the remains deposited in these urns belong to a tribe of human beings who lived during some part of the bronze age, when, as is well known, cremation was practised in many parts of this country.

NOTES ON SOME PHYSICAL FEATURES IN ICELAND.

BY C. W. FENNELL, F.G.S.

(*Read* 17*th November*, 1898.)

PLATE LXVII.

In response to a request from the Council of this Society, I have endeavoured to put into the form of a short paper a few notes and recollections gathered during a visit to Iceland in August and September of the present year.

Iceland just dips into the Arctic Circle in its northern parts, and is less than 250 miles from the coast of Greenland. It is a land of everlasting snow, with an area of 40,000 square miles, and a population of 70,000, with 20 active volcanoes, of which the principal are Oräfa Jökull, 6,410 feet high, Hekla, 5,095, with Vatna Jökull, noted for the great eruption of 1875, and Skaptaa Jökull, which is *said* to have thrown out no less than 40,000 million tons of matter, to have killed over 1,300 human beings, 20,000 horses, 7,000 cattle, and 130,000 sheep in the awful eruption of 1783. The great lava streams that caused this havoc can readily be seen to-day.

Iceland is a volcanic, treeless, mountainous land, wherein dwelleth Frost and Fire. It contains immense lava deserts and drear wastes, with boiling mud and hot springs, with creeping glaciers and snow-covered jökulls. Its bleak and sterile grandeur, aided by a gloriously clear atmosphere, and wonderful sunsets, and brilliant Aurora Borealis, is surely sufficient to stir up enthusiasm and poetry even in the stony heart of a Geologist.

This island is said to be the most extensive area of volcanic rock known. Dr. Thoroddsen, the Geological Surveyor of Iceland under the Danish Government, was exceedingly kind in imparting his knowledge to me on many occasions, and said that the basalt in Iceland is in many places 10,000 feet in thickness. This country is remarkable for the large fissures which run from north to south in the north of the island, and in the south the direction is generally N.E. to S.W. From these fissures in many cases have issued streams of lava, and they are now sometimes marked out with springs of boiling water. Unfortunately the time I had on land did not give me the opportunity of studying these matters of great geological interest so carefully as I should have liked. I am therefore intending to confine my remarks, which shall be very brief, to three physical features which particularly attracted my attention.

1. Weathering and disintegration of the coast line.
2. Characteristic "tussocky" condition of large surface areas.
3. The Icelandic Puzzle—Stone Outlines.

1. Weathering and Disintegration of the Coast.

After spending several days at that most interesting group of Islands, the Færöes, which are situated midway between Scotland and Iceland, and which are entirely volcanic, being built up of lavas and sheets of basalt, forming the characteristic terrace-like escarpments seen on almost every hillside, which (especially in Iceland) are frequently made the more prominent by a line of snow, also noting the flat tops of some of the islands so distinctively of trap formation, it was particularly interesting to note as we travelled north round the coast of Iceland, how the denudation of this magnificent coast was gradually forming what will in æons yet to come be a group of islands very similar to the Færöes in their general appearance.

We are informed that the great volcanic island of Iceland is connected with the Færöes by a submarine volcanic ridge, and Sir Archibald Geikie tells us that nowhere in Europe are the lessons of denudation more eloquently taught than at the Færöes. I think we may say without fear of contradiction that this eloquence is extended to the coast of Iceland, especially between Dyrafjörd and Isafjörd.

The north-west corner of Iceland is a peninsula of very considerable area, connected with the main land by a very narrow neck of land some four English miles in width, and on this portion of the coast we see the grand basalt and lava hills of 3,000 feet in height, with fjörds of all sizes from the parent Isafjörd, with its wide entrance ten miles across and which finds its way inland for 40 miles, to the smaller fjörds, which again have their branch valleys, each with their stream and tributary torrents rushing down the mountain side, which valleys frequently descend from a snow-capped mountain or jökull, and that the dividing hills between these branch valleys have in their turn to give way to the all-powerful denuding influences of frost and sea, wind and storm.

One can easily understand from this object lesson how those peculiar looking islands at the Færöes, such as Naalsö and Kalsö, were formed, and which now appear as long, narrow mountain ranges coming out of the sea. A little more subsidence of the land and we should have a very similar group of islands formed out of this North West Peninsula of Iceland.

It may interest some to hear that the magnetic needle is so much affected off some parts of the mainland that it cannot be relied on as a guide to the navigator.

The most northerly point of Iceland is the edge of a large low-lying plain of pre-glacial lava many square miles in extent.

2.—THE CHARACTERISTIC "TUSSOCKY" CONDITION OF LARGE SURFACE AREAS.

This feature of the country is, owing to its great peculiarity, one of the first things to attract the attention of the traveller, especially if a long ride or walk is made over this rough surface. The appearance has been likened to that of a country churchyard without the tombstones, and if every mound were cut into two or three tussocks it would certainly enable you to realise the most common feature in the Icelandic scenery where there is any vegetation at all.

I have only seen one explanation of this peculiarity, and that is given by the Rev. H. J. Johnson-Lavis, M.D., and he gives the following reasons:—

(1) Irregular lichen covering.
(2) Grasses in separate patches.
(3) Prominent tufts entrap more dust.
(4) If soil is boggy, grass grows best on top of humps.
(5) Swarms of birds fertilise, by their droppings on the top of the hump.

The first two reasons, I think, deal with *effect* rather than cause, and the last three no doubt each give their small quota to the result, some more some less, but I cannot help thinking that the real and primary *cause* of the formation of the tussocks is unmentioned.

I have drawn a small diagram (Fig. 1) which explains my view, that the tussocks or humps are formed much more by the alternation of temperature than by anything else.

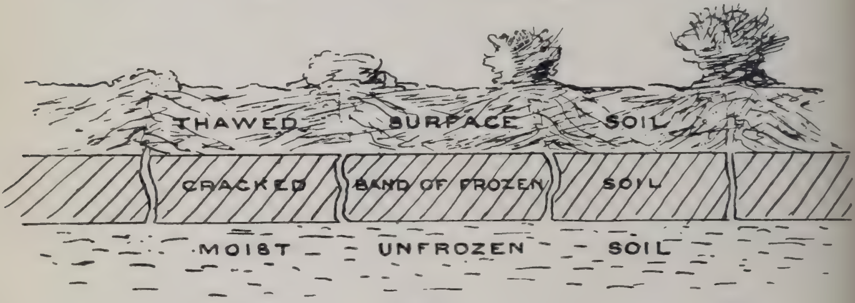


Fig. 1.

Supposing we imagine the ground in its original level condition undrained and full of moisture. In winter the severe frost comes, freezing the ground hard to a depth of 4 or 5 feet, in summer a certain proportion of this frozen ground is thawed, with a band of frozen ground left between the thawed surface and the unfrozen soil below, which is probably well charged with moisture. At certain points it is highly probable that the frozen band will be weakened and cracked, and through such holes or fissures the softer earth will be forced up, probably by the pressure of the frozen or freezing mass above, and like a moleywarp we shall find the accumulation on the surface commencing; the very fact of this surface covering being present tends to keep the frost from any crack formed, thus preserving the weakness of these points for further exudation of the under soil when the thaw sets in again.

We thus gradually get the hump formed of fresh soil, and therefore, perhaps, particularly well suited to support whatever vegetation there is, generally only lichen and moss, and sometimes rough grass, which in their turn tend to increase the size of the tussock.

We must also remember that the fissures mentioned also act as ducts for the moisture from below, and help to support any vegetation in a dry time, when there is no surface moisture.

3.—The Icelandic Puzzle or Stone Outlines.

These curious markings are the sole cause of my promising to read a paper before this Society, owing to a selfish desire to hear the opinions of others expressed thereon. So far as I know, this is one of Nature's curiosities which has not been publicly noticed before.

The diagram (pl. lxvii.), so far as the foreground is concerned, represents a curious surface appearance on a plateau near Hafna Fjörd in the West of Iceland, and not far from Reykjavik, the capital city. I also saw similar markings on a gentle slope at Stykkisholm, some 80 miles further north, but in this case they were not so distinct.

I am sorry to say the diagram is sketched from memory, my camera having unknown to me been so shaken with a 75 mile ride on an Iceland pony that it never spoke again, although in my ignorance of the damage done I took a careful snap shot of this place and many others of equal interest.

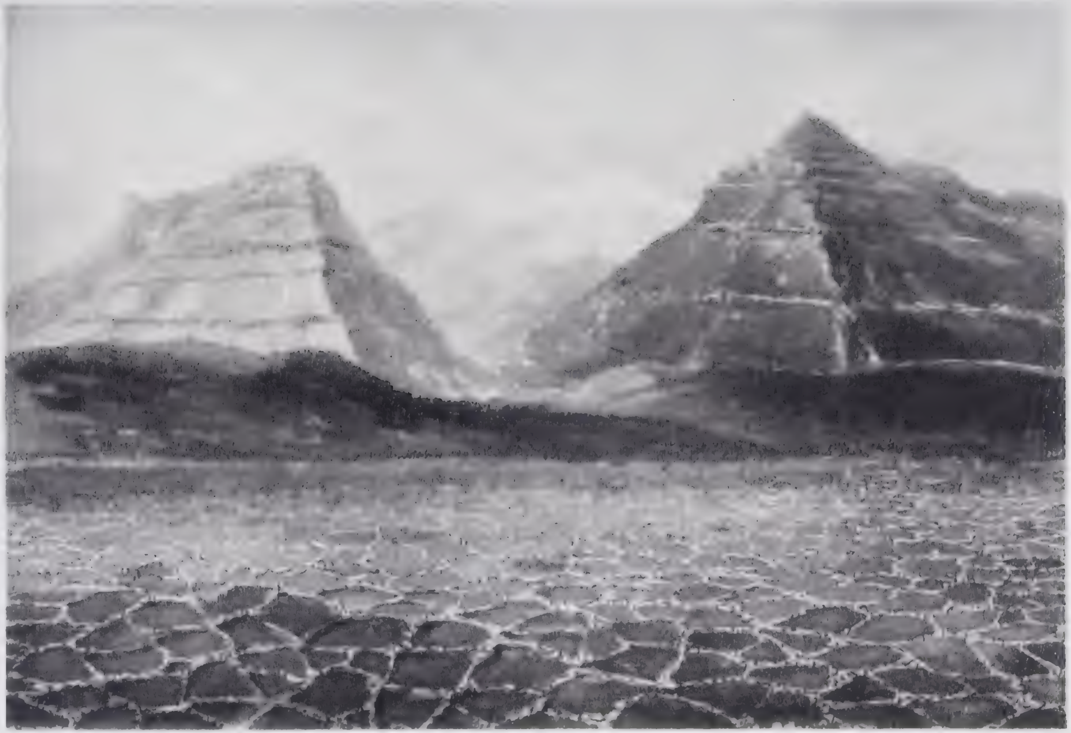
I must also add that if any of you go to Hafna Fjörd you must not expect to see the background as depicted on the diagram. I have simply sketched that in to complete the picture, and also to give you an idea of a typical Iceland scene.

The diagram represents a plateau, on which we have pebbles and boulders of lava and basalt embedded in soft brown earth in a curious mosaic-like pattern as shown. The question to be answered is, How came they to be thus distributed? Some present may read the solution at a glance, or perhaps have seen the same thing elsewhere. I think the diagram makes it easier to solve the difficulty than when looking at the enlarged reality.

Dr. Thoroddsen, who has travelled over Iceland more than anyone else in search of matters of geological and scientific value, was much interested to hear of these markings, which he had never noticed.

Iceland is subjected to severe changes of climate, and, in my opinion, this plateau of lava-earth has been thoroughly wet and turned to mud, which has afterwards been baked and cracked in a hot sun, like the bottom of a dried-up farm pond in a hot summer, or it is possible that the constituents of the soil are such that mere drying would cause the surface to crack in this way owing to contraction.

The cracks might no doubt be considerably widened and deepened by climatic changes, but be this as it may, given the cracks, it is very easy to now picture that in the summer, when the ground is baked hard, or in the winter months, when the ground is frozen, one of the terrific gales so well known in Iceland arises, setting stones and boulders rolling along the hard surface which fall into the cracks previously formed, and fill up every crevice therein, the rest being blown on to find a resting-place elsewhere. In summer we find the soft earth surrounded by the boulders which, in my opinion, mark out the exact sites of former cracks on the hard surface.



MOSAIC-LIKE MARKINGS, ICELAND.

Proc. Yorksh. Geol. and Polytec. Soc., Vol. XIII., Plate LXVII.

CENTRAL PARK
NATURAL HISTORY

ON THE FOSSIL FISHES OF THE UPPER LIAS OF WHITBY. PART IV.

BY ARTHUR SMITH WOODWARD, F.L.S., F.G.S., OF THE BRITISH MUSEUM (NATURAL HISTORY).

PLATES LXVIII.-LXIX.

Family SEMIONOTIDÆ (*continued*).

DAPEDIUS MICANS, Agassiz, MS.

1844. *Dapedius micans*, L. Agassiz, Poiss. Foss., vol. ii., pt. i., p. 304 (name only).

Type: Specifically indeterminable scales; British Museum.

The laterally-compressed, round-bodied ganoid fishes of the genus *Dapedius* are abundant in the Upper Lias of Würtemberg; but, so far as the present writer is aware, they are only represented as yet by unsatisfactory fragments among the fossils from Whitby. It is true that Agassiz (*op. cit.*, vol. ii., pt. i., p. 218) mentions "two very beautiful examples" of *Dapedius orbis* from "the Liassic shales of Whitby," as having been exhibited by the Rev. M. Williams at the meeting of the British Association at Dublin in 1835. This species, however, is a typically Lower Liassic form, only definitely known from Barrow-on-Soar in Leicestershire; and as the specimens said to have been exhibited at Dublin have not been subsequently traced or noticed, it seems probable that there was a mistake concerning their origin. The record of *Dapedius ovalis* from Whitby (*Tetragonolepis ovalis*, Agassiz, *op. cit.*, vol. i., p. 39) is equally uncertain; though as this is an Upper Lias form in Würtemberg, it is more likely to occur than the previously-mentioned species.

The only fragment of *Dapedius* from Whitby which has received a distinctive specific name is a portion of the squamation in the collection of the late Sir Philip Egerton (now in the British Museum, No. P.515), intended by Agassiz to be described as the type specimen of *Dapedius micans.* The scales are somewhat deeper than long, and apparently not serrated at the hinder border. Their exposed face seems to be abraded in the fossil, but the scales of the middle of the flank are clearly not tuberculated, and only marked by slight oblique corrugations. Such a specimen is, of course, inadequate for the purposes of a specific diagnosis.

Family BELONORHYNCHIDÆ.

BELONORHYNCHUS ACUTUS, Agassiz, sp.

1844. *Belonostomus acutus*, L. Agassiz, Poiss. Foss., vol. ii., pt. ii., p. 142, pl. xlvii. *a*, figs. 3, 4.

1858. *Belonorhynchus ? acutus*, H. G. Bronn, Neues Jahrb., p. 12.

1876. *Belonostomus acutus*, J. F. Blake, in Tate and Blake, Yorkshire Lias, p. 259.

1887. *Belonorhynchus acutus*, K. A. von Zittel, Handb. Palæont., vol. iii., p. 222.

1895. *Belonorhynchus acutus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii., p. 14, pl. ii., fig. 1.

Type: Imperfect skull; British Museum.

In 1844, Agassiz described and figured an imperfect skull and a fragment of jaw "from the Whitby Lias," denoting a fish with a low cranium and extremely attenuated snout. He supposed at the time that these fossils belonged to his Jurassic genus *Belonostomus*, which had a skull of very similar general proportions; but as they seemed to have the snout "more slender than in any other species, and especially more gradually tapering than that of *B. muensteri*," which was the next most slender form, he proposed to regard the Whitby specimens as representing a new species, *B. acutus.* At the same time he recognised a nearly similar skull in the Lower Lias of Lyme Regis, and briefly recorded it (*tom. cit.*, pt. ii., p. 143) under the name of *B. anningiæ.* In 1858,* Quenstedt discovered the same type of skull in the Upper Lias of Würtemberg; and in this year also Bronn described and figured a small fish from the Triassic shales of Raibl, in Carinthia, which clearly exhibited a similar head fixed to a trunk which was certainly not that of *Belonostomus.* Bronn accordingly gave the new generic name of *Belonorhynchus* to the Triassic fish, and incidentally remarked that the so-called Liassic species of *Belonostomus* would also probably prove to be wrongly named and belong to this newly recognised genus. Thirty years afterwards definite proof of the accuracy of Bronn's prediction was discovered in the Lower Lias of Lyme Regis;† and it is now quite certain that the Liassic skulls in question belong to a fish resembling *Belonostomus* only in outward shape, zoologically inferior to the latter in the structure of the fins and in the absence of vertebral centra, also differing in the absence of a continuous covering of scales.‡ In *Belonorhynchus*, indeed, the trunk is only protected by four isolated longitudinal series of comparatively small scutes, which form a dorsal and ventral ridge and a support for the slime-canal of the "lateral line" on each side.

Professor Blake doubts the origin of the type specimens of *B. acutus* described and figured by Agassiz, owing to the lack of subsequent confirmatory discoveries. He supposes them to have reached Whitby from Lyme Regis in the ordinary course of trade, which was once brisk between the fossil dealers of Yorkshire and Dorsetshire. These doubts are still further emphasised by the apparent specific identity of the original fragments with skulls which are common in the Lower Lias of Lyme Regis; for there is as yet no definite proof of the range of any species of fish from the Lower to the Upper Lias. The type specimens in question, however, were acquired by the British Museum with the collections of the late Earl of Enniskillen and Sir Philip Egerton in 1882, and it is thus possible now to compare them carefully with ample material. Mr. Etheridge has kindly examined them and made such careful comparisons, with the result that he considers they must be regarded as true Whitby fossils.

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* F. A. Quenstedt, Der Jura, p. 234.

† A. S. Woodward, "Note on the Early Mesozoic Ganoid, *Belonorhynchus*," Ann. Mag. Nat. Hist. [6], vol. i. (1888), pp. 354-356.

‡ A. S. Woodward, "The Fossil Fishes of the Hawkesbury Series at Gosford," Mem. Geol. Surv. N. S. Wales, Palæont. No. 4 (1890), p. 22.

The imperfect Upper Liassic skull which must thus be regarded as the type specimen of *Belonorhynchus acutus* is seen in left side-view, as represented in Agassiz's figure (*tom. cit.*, pl. xlvii. *a*, fig. 4), and exhibits the characteristic backward extension of the cranial roof. The orbital rim is much broken, but the extremely attenuated rostrum is indicated apparently throughout its entire length, and there are traces of the sharply-pointed large teeth in its anterior portion. As preserved, the outer face of the cranial roof is finely punctate and rugose, while the ornament on the rostrum tends towards wavy longitudinal striations. Where the outer face of the rostrum is broken away towards its anterior end, an internal cavity filled with calcite is exposed.

The second specimen noticed and figured by Agassiz (pl. xlvii. *a*, fig. 3) is regarded by him as a fragment of a mandible. As, however, this fossil also exhibits a central cavity filled with calcite towards its anterior extremity, it is probably another example of the rostrum. The degree of tapering is approximately as in the former specimen. Assuming this interpretation to be correct, the hinder half of the fossil and its anterior quarter exhibit the inner face of the right side of the snout, while the intervening region is complete and a portion of its calcite-core projects in front. There are remains of the characteristic teeth, but their size and state of preservation are exaggerated in the original figure.

As already mentioned, complete heads with a cranium of similar proportions to that named *B. acutus* are known from the Lower Lias; and, in the absence of all evidence that the trunk differed in the two forms to which these heads belonged, it is necessary to record them provisionally under one and the same specific name. The head of the Lower Lias fish is from four and a half to five times as long as its maximum depth; the distance between the orbit and the occiput considerably exceeds the maximum depth of the mandible, while the angular bone of the latter is much truncated though gently rounded postero-inferiorly. Its superficial ornamentation consists of short rugæ, the majority directed longitudinally.

Belonorhynchus brevirostris, A. S. Woodward.

1858. *Belonostomus acutus*, F. A. Quenstedt (*errore*), Der Jura, p. 234, pl. xxix., fig. 8.

1892. *Saurorhynchus acutus*, O. M. Reis, Geogn. Jahresh. 1891, p. 145 (in part), figs. 1-3.

1895. *Belonorhynchus brevirostris*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii., p. 17, pl. ii., fig. 2.

Type: Head from Lower Lias, Lyme Regis; British Museum.

The fine head of *Belonorhynchus* from the Upper Lias of Würtemberg, referred by Quenstedt to *B. acutus*, differs considerably from the typical Whitby skull in its greater depth and shorter rostrum; and similarly short and deep skulls are also known from the Lower Lias of Lyme Regis, associated with the elongated type already described. These fossils are therefore now regarded as representing a distinct species, *B. brevirostris*.

Only one example of this comparatively short skull claimed to be a Whitby fossil, is known to the present writer, namely, an abraded specimen from Dr. Bowerbank's collection in the British Museum (No. 39,153). An examination apparently of this specimen caused Professor Blake to doubt the record of its origin (*op. cit.*, p. 259); but the matrix in which it is preserved seems to bear much more resemblance to the Alum Shale of Whitby than to the tenacious clayey deposit in which the skulls ordinarily occur at Lyme Regis. The late Mr. William Davies' original label is thus probably correct.

This specimen, shown of the natural size in the accompanying photograph (fig. 1), lacks the posterior extension of the cranial roof, but is otherwise well displayed in right lateral aspect. Its outer surface is remarkably smooth and thus apparently abraded; but there still remain traces of the characteristic rugose and partly punctate ornamentation. The margin of the orbit (*orb.*) is distinct, while the oblique, ovate, narial opening (*na.*) is also recognisable. The hinder portion of the mandible is slightly deeper than the cranium above it; and the sutural line delimiting the relatively large angular bone (*ag.*) is conspicuous. The large teeth are distinct, but mostly shown only in abraded section.

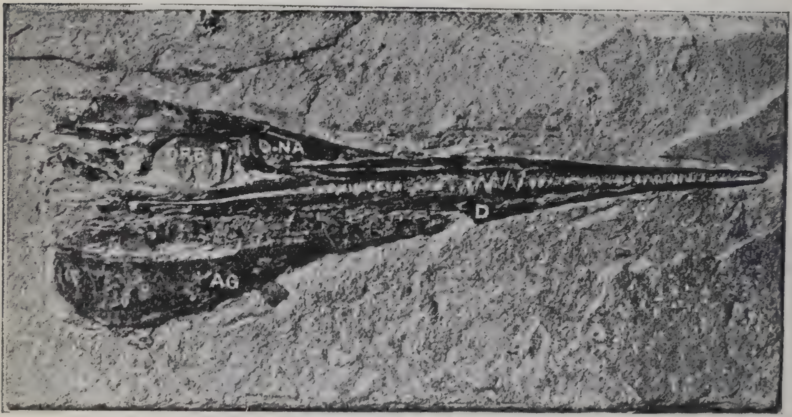


Fig. 1.—*Belonorhynchus brevirostris*, A. S. Woodw.; skull and mandible, right lateral aspect, nat. size. *ag.*, angular bone; *d.*, dentary bone; *na.*, narial opening; *orb.*, orbit. [Brit. Mus., No. 39153.]

The specimen just described, considered in connection with others both from the Lower Lias of Lyme Regis and the Upper Lias of Würtemberg, renders it possible to append the following *specific diagnosis*:—Head from three and a half to four times as long as its maximum depth; distance between the orbit and occiput scarcely, if at all, exceeding the maximum depth of the mandible, and the angular bone of the latter, with long, nearly vertical hinder border, sharply rounded off inferiorly; dentition powerful, the posterior laniaries widely spaced and especially robust; superficial ornament consisting of short rugæ, the majority directed longitudinally.

Family CHONDROSTEIDÆ.

GYROSTEUS MIRABILIS, Agassiz, MS.

Plates LXVIII.-LXIX.

1834-44. *Gyrosteus mirabilis*, L. Agassiz, Poiss. Foss., vol. i., p. 19, and vol. ii., pt. ii., p. 179 (undefined).

1855. *Sepia incomposita*, M. Simpson, Foss. Yorkshire Lias, p. 21.

1858. *Gyrosteus mirabilis*, P. M. G. Egerton, Phil. Trans., p. 883.

1876. „ „ J. F. Blake, in Tate and Blake, Yorkshire Lias, p. 256, pl. ii., figs. 2, 3.

1889-90. „ „ A. S. Woodward, Proc. Geol. Assoc., vol. xi., p. 32, figs. 2-7; and The Naturalist, 1890, p. 101, figs. 1-6.

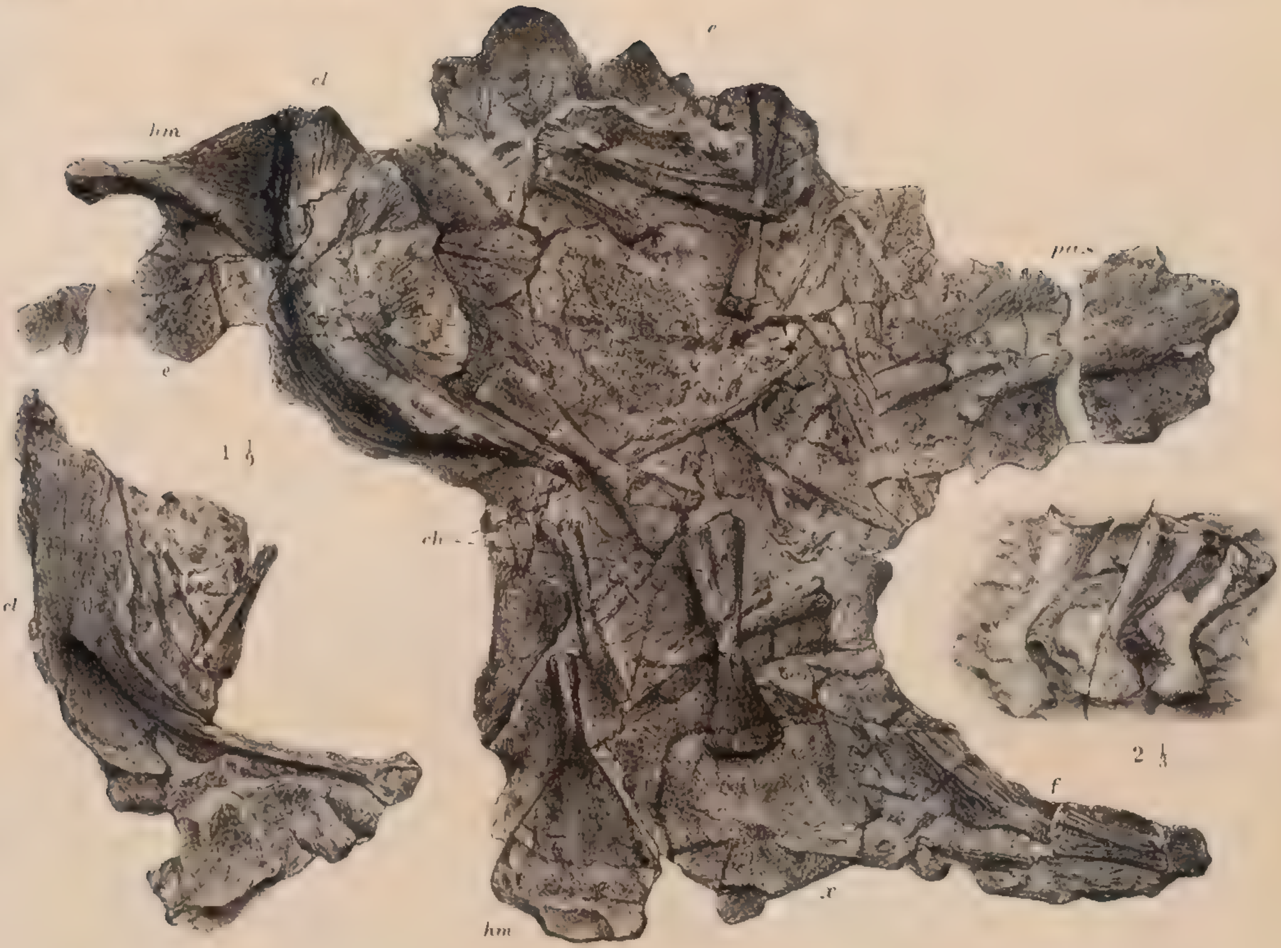
1895. „ „ A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii., p. 34, figs. 7, 9, 10, 12-14, 16, 17.

Type: Various bones; British Museum.

When visiting Whitby in 1834, Agassiz observed "some gigantic fragments of a fish which certainly surpassed in size all those of which traces had hitherto been discovered." He regarded these fossils as comprising "the bones of the head, among others a frontal bone more than a foot in length, and some broken branchial arches, with fragments of fins." He noted the remarkable absence of teeth among the remains of "this marine giant," and proposed to name the fish *Gyrosteus* —doubtless in allusion to the twist in the characteristic bone which is identified below as hyomandibular. Subsequently he recorded the species, without description, under the name of *Gyrosteus mirabilis*, still regarding it as the largest known fish; and he eventually considered it to be allied to his rather heterogeneous group of "Célacanthes." In 1858, Sir Philip Egerton published a memoir on the sturgeon-like fish, *Chondrosteus acipenseroides*, from the Lower Lias of Lyme Regis, and appended a footnote expressing the opinion that "the gigantic fossil fish of the Whitby Lias, named by Agassiz *Gyrosteus mirabilis*, belongs to the Sturionidæ, and is nearly allied to *Chondrosteus*." In 1876, Prof. J. F. Blake published a few notes on some of the specimens in the Yorkshire museums, but did not attempt an exhaustive treatment of the subject. His "large humerus (?)" is evidently the hyomandibular bone, while his problematical "radius or ulna" seems to be the ceratohyal. His "neural arch of vertebra" (*op. cit.*, p. 257) or "spine" (*ibid.*, p. 9., pl. ii., fig. 2) must be regarded as a caudal ridge-scute. Between the years 1889 and 1895 the present writer published further details of the osteology of *Gyrosteus*, confirming Egerton's suspicion of its close relationship to *Chondrosteus*; and a complete summary of our knowledge of the fish up to the latter date is given in the British Museum Catalogue, pt. iii.

According to Martin Simpson, who described one fragment of bone in the Whitby Museum under the name of *Sepia incomposita*, the remains of *Gyrosteus mirabilis* occur in the compact bituminous shale immediately above the jet rock, which yields most of the fishes of the Whitby Lias. The large bones in collections are usually isolated and imperfect, frequently damaged by decaying pyrites; and no complete head or any segment of the trunk has hitherto been excavated and preserved.

The finest known slab of *Gyrosteus mirabilis* was purchased by the British Museum in 1861. It is represented of one-ninth the natural size in pl. lxviii., fig. 1, and shows the scattered group of bones precisely as they were found, except that the separate fragment with the supraclavicle (*s.cl.*) originally formed a continuation of the angle marked *f*, and was removed for convenience of framing and preservation. To



J. Green del. et lith.

Mintern Bros. imp.

GYROSTEUS MIRABILIS

the extreme right above, the imperfect parasphenoid (*pas.*) lies horizontally with exposed inferior face and its bifurcating posterior end turned to the left. Its anterior end is seen to be slightly expanded, but its middle portion is obscured by a transverse fracture. The hyomandibular bone (*hm.*) of each side is preserved, the one at the extreme left above, slightly overlapped by the clavicle (*cl.*), the other at the left lower angle of the slab. Two slender, hour-glass-shaped bones, about as long as the hyomandibular, are probably the pair of ceratohyals (*ch.*). Other more imperfect and more slender rod-shaped bones may perhaps represent the branchial arches. Various fragments of plate-like bones (*e*) exhibit traces of coarse tuberculations

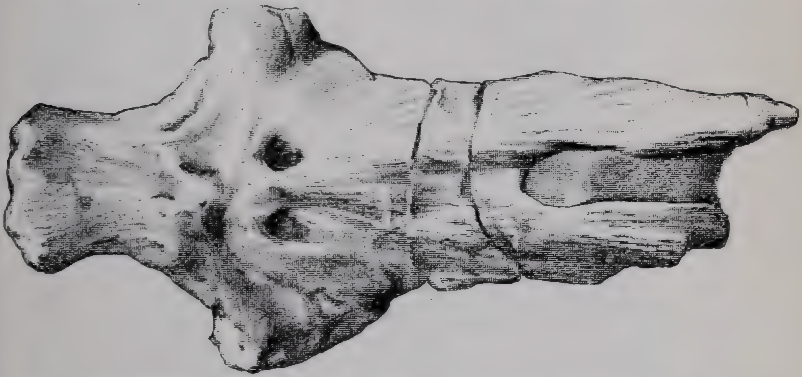


Fig. 2.—*Gyrosteus mirabilis*, Ag., MS.; imperfect parasphenoid, inferior aspect, one-fourth nat. size. [Brit. Mus., No. P.2262*a*.] (From Catal. Foss. Fishes, B.M.)

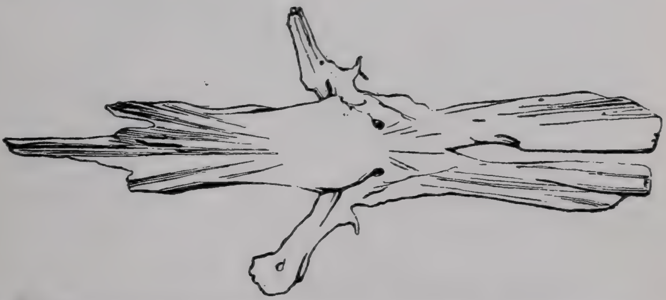


Fig. 3.—Parasphenoid of recent sturgeon (*Acipenser*), inferior aspect, much reduced. (From Catal. Foss. Fishes, B. M.)

without enamel, and evidently belong to the outer covering of the skull. None of these can be identified; but one nearly quadrangular piece (*x*) is larger and better preserved than the others, and shows the external tubercles disposed more or less along the radiating lines of growth. This bone also exhibits a triangular area on the right which is free from tubercles and

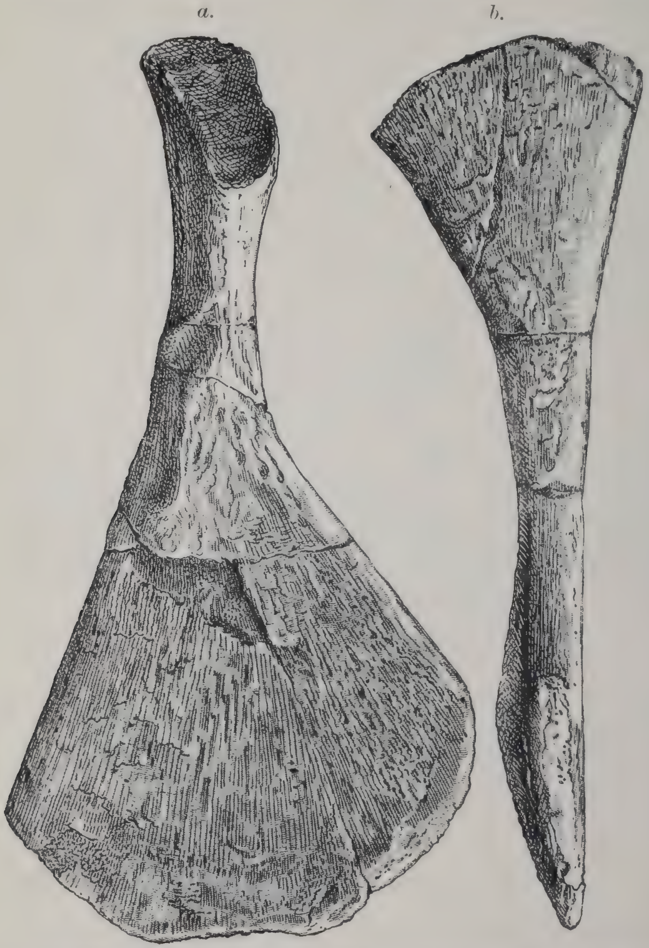


Fig. 4.—*Gyrosteus mirabilis*, Ag., MS.; right hyomandibular, lateral aspect (*a*) and posterior aspect (*b*), one-third nat. size. [Brit. Mus., No. P.3356*a*.]

is possibly an overlapped surface. The largest bones in the group are the left clavicle (*cl.*) shown in outer aspect, and the left supraclavicle (*s.cl.*) seen from within. The lower end of the latter (turned downwards in the figure) is produced into a considerable rod-like extension. A few remains apparently of fin-rays (*f*) are also observable on the right of the slab.

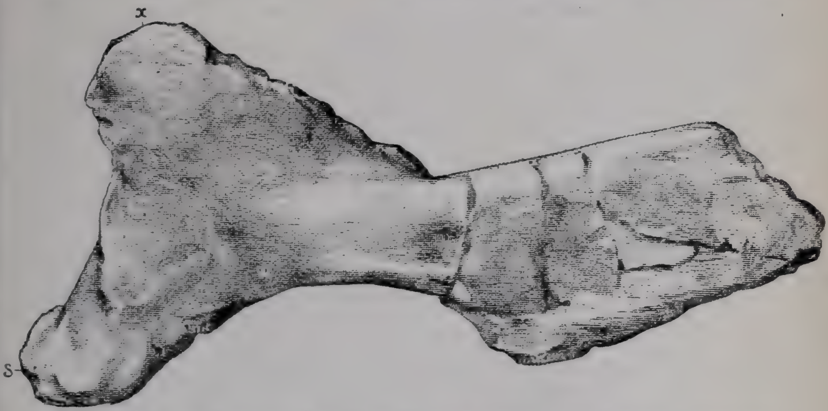


Fig. 5.—*Gyrosteus mirabilis*, Ag., MS.; left maxilla, outer aspect, one-fourth nat. size; *s.*, anterior symphysial extremity; *x.*, palatine process. [Brit. Mus., No. P.3356*l.*] (From Catal. Foss. Fishes B. M.)

The best parasphenoid hitherto discovered is shown of one-quarter the natural size in fig. 2. It is imperfect in all directions, and especially in front; but a comparison of the parts preserved with the parasphenoid of the modern sturgeon (fig. 3) shows that the two bones are essentially identical. The posterior bifurcation and the pair of carotid foramina at the base of the lateral basipterygoid processes are distinct.

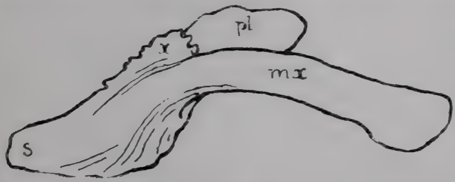
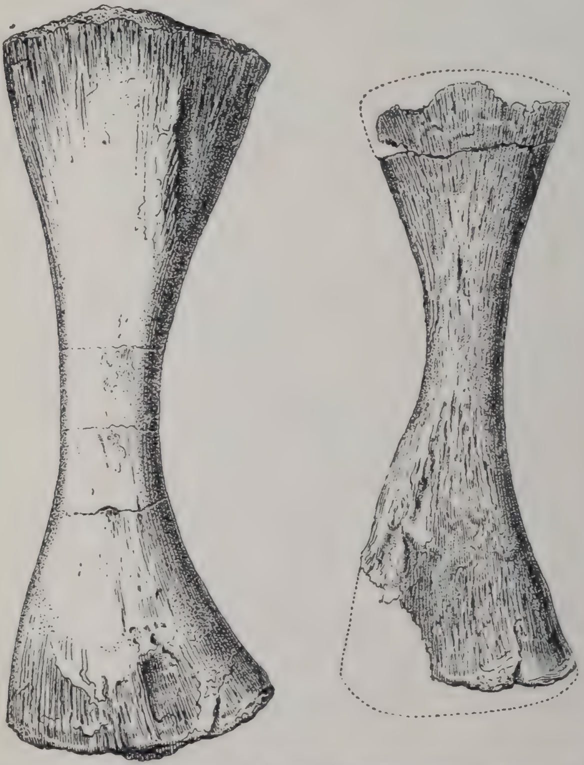


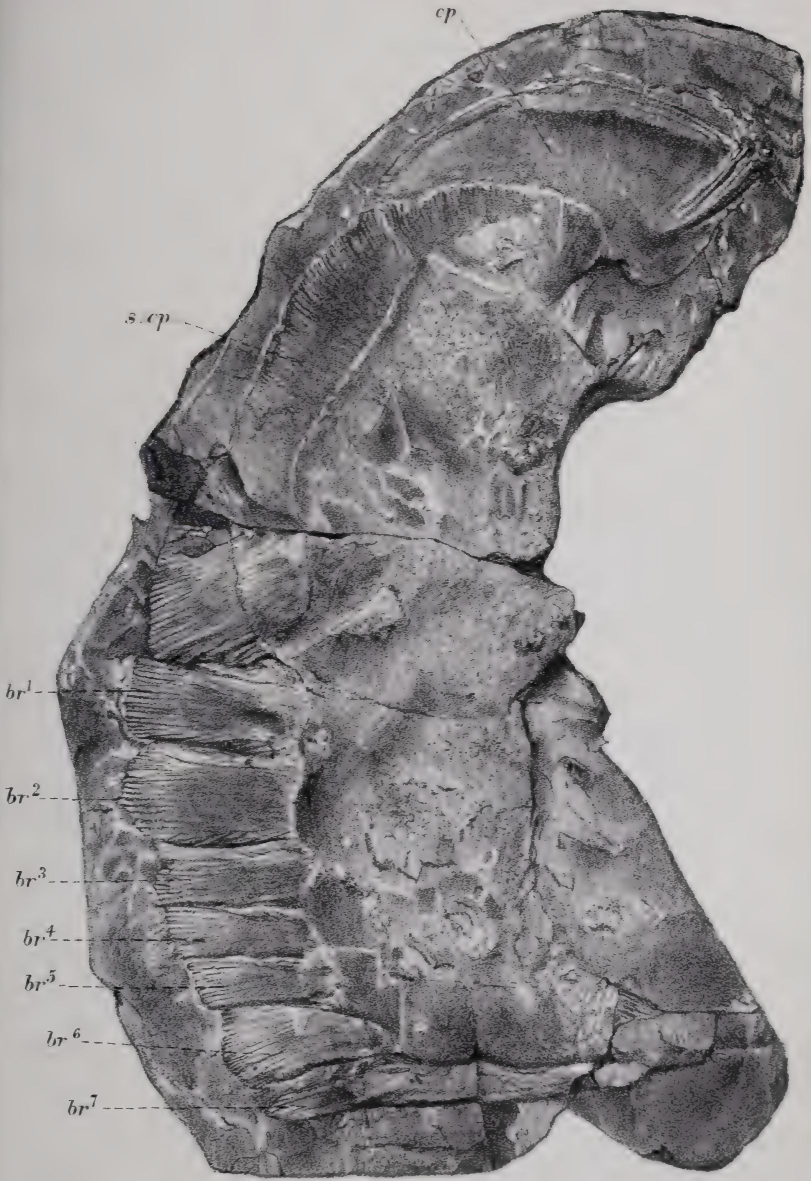
Fig. 6.—Left maxilla (*mx.*) and palatine (*pl.*) of recent sturgeon (*Acipenser*), outer aspect, much reduced. (From Catal. Foss. Fishes B. M.)

Numerous specimens of the hyomandibular are known, and one of the best and largest in the British Museum is shown of one-third the natural size in fig. 4. The bone is much constricted somewhat above its middle. Its comparatively small upper portion is compressed antero-posteriorly, while its much expanded lower portion is still more compressed laterally. It thus resembles the hyomandibular of the modern sturgeon in shape, only differing from the latter in the greater extent of the ossification in its lower expanded portion.



Figs. 7, 8.—*Gyrosteus mirabilis*, Ag., MS.; ceratohyals, one-third nat. size. [Brit. Mus., Nos. P.2262*c*, 43304.]

Of the maxilla only a single example is yet known, in the collection of the late Earl of Enniskillen (Brit. Mus., No. P.3356*l*). It is of the left side and an outer view of it is given in the accompanying fig. 5. It differs considerably in



$\frac{1}{3}$

J. Green del. et lith. Mintern Bros. imp.

GYROSTEUS MIRABILIS

shape from that of *Chondrosteus*, and more closely resembles that of the modern sturgeon (fig. 6). It agrees with the latter in its arched form, expanded anterior end, and a well-developed expansion (x) for articulation with the palatine element; but it differs in the relatively greater steepness of its anterior border, and in the straightness, shortness, and posterior expansion of its hinder half.

The slender hour-glass-shaped bone already mentioned as probably being ceratohyal is about as numerous as the hyomandibular, and two detached specimens in the British Museum are shown in the accompanying figs. 7, 8. They appear to be somewhat more slender than the corresponding element in *Chondrosteus* and the sturgeon.

One nodule from the bed immediately above the jet rock, obtained from a Whitby dealer by the present writer in 1895, almost certainly exhibits the left opercular apparatus from the inner aspect, and is the only known specimen displaying this part of the skeleton. It is shown of one-third the natural size in pl. lxix. An intractable mass of pyrites unfortunately obscures part of the fossil from the top of the suboperculum downwards, and there is a crack across the latter element near its lower end; but the essential characters of the bones are observable. The operculum (*op.*) is a comparatively small plate, truncated in front, and rounded postero-superiorly: it is strengthened by two nearly vertical but slightly convergent ridges, which extend downwards from its point of suspension. The suboperculum (*s.op.*) is remarkably narrow and deep, its total depth being about three times as great as the maximum depth of the operculum. Its radiating structural fibres cause a slight fimbriation of its upper, lower, and hinder borders. Beneath this plate follow seven branchiostegal rays ($br.^{1\text{-}7}$) in natural order, all fimbriated at the truncated hinder border, but otherwise smooth on the inner face. These diminish in width downwards, so that the lowest is the most slender, but the diminution is by no means regular or gradual. If this fossil be correctly interpreted, it is therefore evident that

Gyrosteus differs from the sturgeon but agrees with *Chondrosteus* in the presence of an extensive branchiostegal apparatus.

The vertebral axis is practically unknown, but one fragment in the British Museum (No. P.3356*m*) seems to exhibit five of the neural or hæmal arches without their appended spines. These arches are in regular series, and three of them are shown of one-third the natural size in pl. lxviii., fig. 2. They are more expanded in their basal half than the neural arches in *Chondrosteus*,* and they seem to have been closely pressed together, without any intercalary pieces; but the hard matrix obscures their precise shape. Above the basal half they

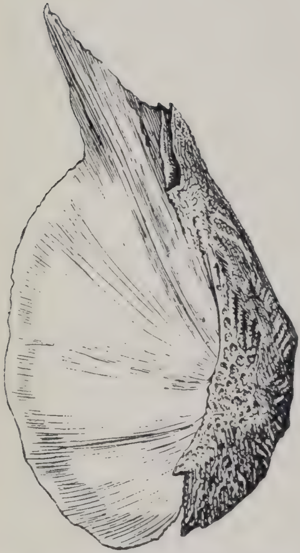


Fig. 10.—Left clavicle of recent sturgeon (*Acipenser*), outer aspect, much reduced.

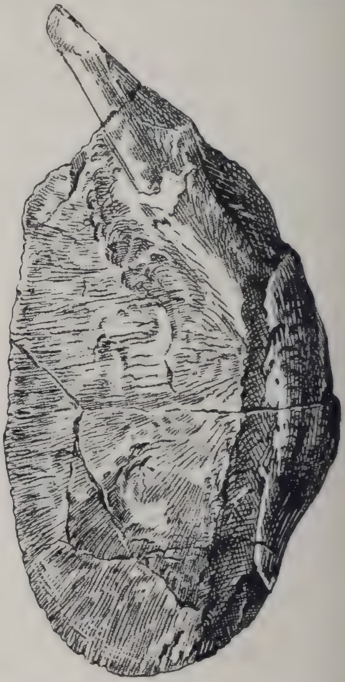


Fig. 9.—*Gyrosteus mirabilis*, Ag., MS.; left clavicle, outer aspect, one-sixth nat. size. [Brit. Mus., No. P.3356*d*.]

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[*] Cf. Catal. Foss. Fishes B. M., pt. iii., pl. i., fig. 4.

are constricted, then more sharply turned backwards, and slightly expanded at their truncated distal end.

The clavicle has been already mentioned in the large group (pl. lxviii., fig. 1, *cl.*), but a still finer specimen is represented from the outer aspect in the accompanying fig. 9. This bone is identical in shape with the corresponding element both in *Chondrosteus* and in the sturgeon (fig. 10). The supraclavicle has also been identified in the large group; but another characteristic example, wanting the inferior process, is perhaps more clearly represented from the inner aspect in fig. 11.

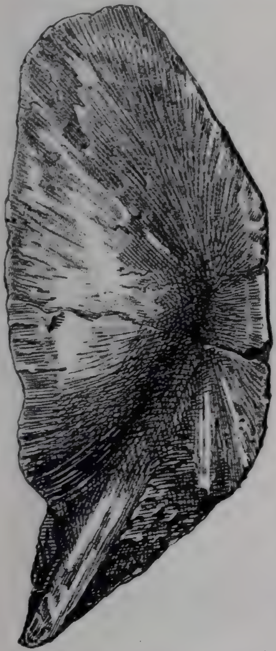

Fig. 11.—*Gyrosteus mirabilis* Ag., MS.; right supraclavicle, inner aspect, one-sixth nat. size. [Brit. Mus., No. P.3356*b*.]

As might be expected, the fins are very imperfectly known. One fragment in the British Museum (No. P.3356*n*) comprises a series of unjointed rays, the longest piece preserved being 0·5 m. in length; it may have been part of the pectoral, but its exact position in the fin-skeleton cannot be determined. It clearly formed an anterior margin, and its rays gradually increase in length backwards, terminating successively at the border. The two parallel rods of which each ray is composed are fused together at the pointed distal end. Most fragments of the fins of *Gyrosteus*, however, exhibit very closely articulated rays; and a good example, which probably belongs to the tail, is shown in fig. 12. In this specimen the rays are unjointed for a short distance at their inserted end, but they soon become crossed by closely-arranged sutures, and nearer their extremities they bifurcate once or twice. It may be added that one small fin in Mr. Samuel Chadwick's collection in the Malton Museum, probably a pectoral of *Gyrosteus*, exhibits the minute superficial points or granules of ganoine well known on the pectoral fin of *Chondrosteus*.

No scales or dermal plates have been observed among the remains of *Gyrosteus*, and the body was thus probably naked, as in *Chondrosteus*. It is indeed strange that no traces have hitherto been found of the lozenge-shaped scales which invest the upper lobe of the tail in all known sturgeon-like fishes, recent and extinct; but the upper border of the tail is ridged in the usual manner by a row of great saddle-shaped, overlapping scutes, which form a serried armour. Two small examples of these scutes are preserved in Mr. Chadwick's

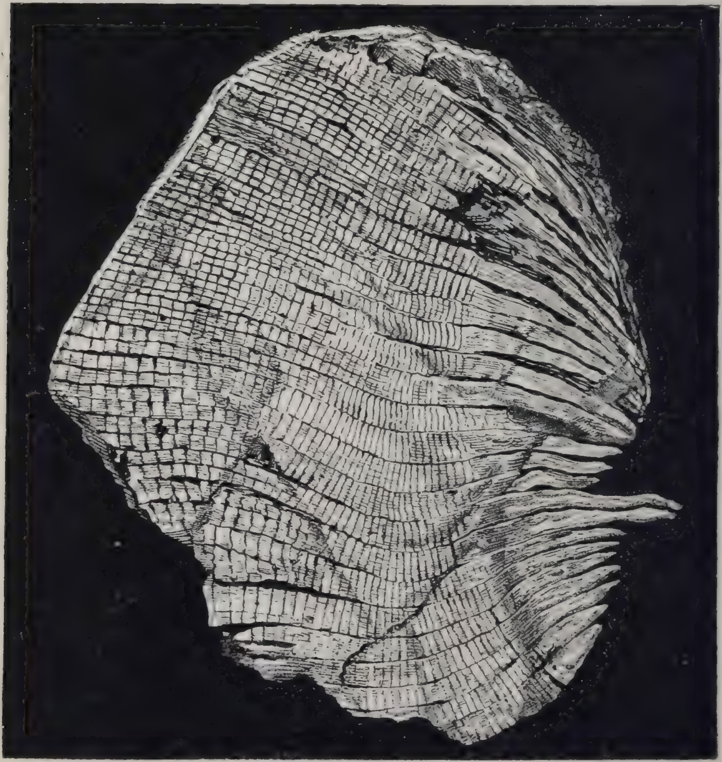

Fig. 12.—*Gyrosteus mirabilis*, Ag., MS.; fragment of caudal fin, one-third nat. size. [Brit. Mus., No. P.3356*c*.]

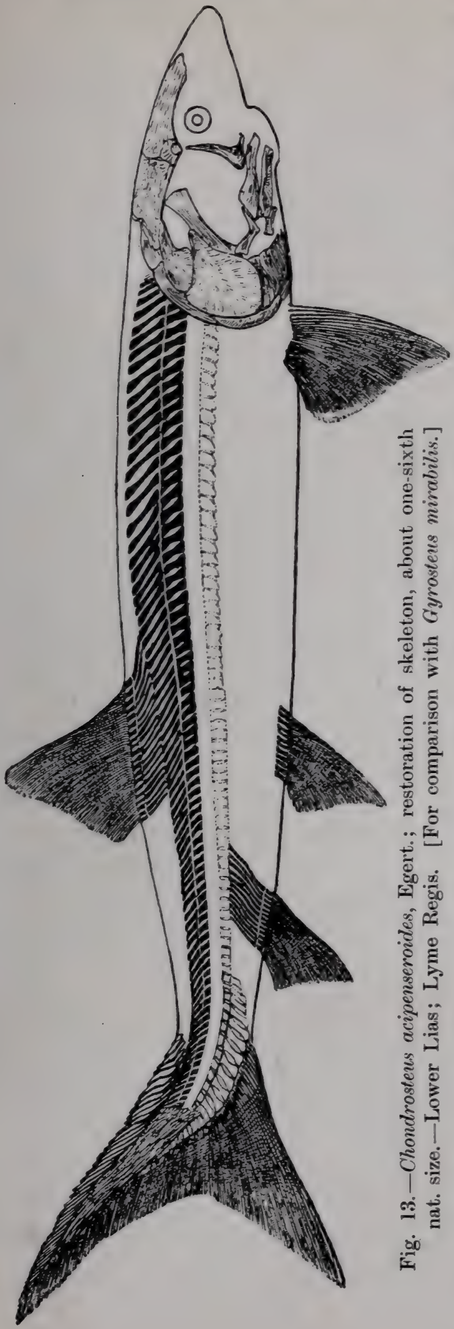

Fig. 13.—*Chondrosteus acipenseroides*, Egert.; restoration of skeleton, about one-sixth nat. size.—Lower Lias; Lyme Regis. [For comparison with *Gyrosteus mirabilis.*]

collection in the Malton Museum; while a few specimens from a very large tail are to be seen in the York Museum. The scutes are bilaterally symmetrical, flattened, and taper to an acute apex; they are destitute of an external layer of enamel, and the only traces of ornamentation are feeble rugæ on the exposed sides. The largest specimens at York measure about 0·12 m. from the apex to the bifurcation at the base.

So far as can be judged from the foregoing description, the only definitely known character by which *Gyrosteus* is distinctly separated from *Chondrosteus* is afforded by the shape of the maxilla. It is therefore of interest to append a restored figure of *C. acipenseroides* (fig. 13), founded on nearly complete skeletons from the Lower Lias of Lyme Regis. On this basis it seems possible to estimate the approximate length of the largest individuals of

Gyrosteus mirabilis indicated by the known remains. The largest hyomandibular of the latter measures 0·35 m. in length, while the largest clavicle attains 0·57 m. in maximum height. In *Chondrosteus* the length of the hyomandibular is contained about 16 times, and the maximum depth of the clavicle between 8 and 9 times in the total length of the fish. The largest individuals of the Whitby species thus probably attained a length of from 5 to 6 metres.

A smaller form probably of *Gyrosteus* is represented by some small bones in the British Museum from a comparatively soft stratum at an unknown horizon in the Whitby Lias (recorded in Catal. Foss. Fishes B. M., pt. iii., p. 42).

Explanation of Plates.

Plate LXVIII.

Fig.		Page.
1.	*Gyrosteus mirabilis*, Ag., MS.; slab exhibiting group of bones, one-ninth nat. size. *Ch.*, ceratohyal; *cl.*, clavicle; *e.*, external bone, tuberculated; *f.*, fin-rays; *hm.*, hyomandibular; *pas.*, parasphenoid; *s.cl.*, supraclavicle; *x.*, undetermined external bone, tuberculated. [36185.]	462
2.	*Gyrosteus mirabilis*; three vertebral arches, one-third nat. size. [P.3356*m.*]	468

Plate LXIX.

1.	*Gyrosteus mirabilis*, Ag., MS.; left opercular apparatus, inner aspect, about one-third nat. size. *Br.*$^{1-7}$, branchiostegal rays; *op.*, operculum; *s.op.*, suboperculum. [P.7520.]	467

The specimens represented on these plates are preserved in the British Museum, and the numbers in square brackets refer to the Register of the Department of Geology.

In Memoriam.

JAMES SPENCER.

Of the many amateur geologists whom Yorkshire has produced, few have done more good work and contributed more to the sum of geological knowledge than Mr. James Spencer, of Halifax. He was born of humble parents at Luddenden in 1834, and soon after came to reside at Halifax.

Being poor, his parents were obliged to send him to work in Charlestown Brick Works at an early age, and his education became much neglected. His facilities for obtaining knowledge were at a discount until he joined the Working Men's College at Haley Hill, Halifax, which about this time had been founded by the late Colonel Akroyd. Here he met Mr. J. W. Davis, Mr. Halliday, and others, and was soon after induced to join the evening classes and go in for most of the subjects taught at the college. After some years of diligent study, and by his indomitable perseverance, he not only succeeded in obtaining a general education, but successfully passed examinations in geology, chemistry, history, geography, and languages. His rapid progress in learning was noticed by Colonel Akroyd, who subsequently employed him in the warehouse of his mill, and some years after appointed him cashier at the works in Haley Hill. This post he held up to about ten years ago, when he retired.

When a mere boy, and employed at the brickyard, he noticed the curious markings on the shale which the workmen dug from the pit, and on learning that these were called fossils, and that they were relics of extinct living things, young Spencer commenced to take an interest in them. As he grew up into manhood his love for geology became so great that be bought what books he could afford bearing on the subject and carefully studied them. He thus succeeded in obtaining a good, sound, theoretical knowledge of science. Not content with mere book-learning, he at the same time studied assiduously the rocks and fossils in the Carboniferous strata around Halifax.

By the year 1851 he had accumulated sufficient information to enable him to begin an independent and systematic investigation of the Millstone Grits and Coal Measures of his native district, and to make sections of the various exposures of the rocks. When his work in the mill was over, Mr. Spencer might be seen at his favourite pursuit either indoors or in the field, the weather seeming to have no effect in damping his ardent spirit.

Wet or fine, with hammer and bag, he would start on his rambles each Saturday afternoon and trudge for miles over hill and dale, studying the rocks and collecting fossils on his way, and would often come home late at night cold, hungry, and wet, carrying a heavy load of stones as the results of his toilsome journey. His winter nights were mostly spent at home, labelling and classifying his specimens of rocks and fossils. His holidays were mostly spent in excursions to other districts in order to study the various geological formations. Besides all this, he seems to have found ample time to write papers and read them before local and other societies, most of them being descriptions of his own work. He also contributed articles on geological subjects to monthly magazines and other periodicals, notably a twopenny monthly paper entitled the *Circulator*, which was commenced in 1866 by the Haley Hill Literary and Scientific Society. The *Circulator*, although short-lived, contained several interesting and valuable articles of geology by Mr. Jas. Spencer. The two first numbers contain an introduction to "Popular Geology." After this came two papers on the strata of Halifax. Other articles are on the coal pits at Low Moor and the geology of Ingleborough. We next find Mr. Spencer contributing papers to the Manchester Geological Society and the Yorkshire *Naturalist* on the stratigraphical geology of the Millstone Grits and Coal Measures in and around Halifax. Mr. Spencer was an active member of the Halifax Scientific Society from its commencement until his death, and served as Vice-President. He was also for many years a member of the Ovenden Naturalists' Society and the Yorkshire Naturalists' Union. At the latter society he was on the General Committee, also on the Boulder Committee, and in 1896 was elected Chairman of the Yorkshire Fossil Flora Committee.

The favourite haunts of his study of geology were the coal pits at Low Moor and at Clifton, near Brighouse, also at Beacon Hill and in the valley of Shibden. High Green Wood and Horse Bridge Clough, above Hebden Bridge, were often visited by Mr. Spencer when investigating and collecting fossils from the Yoredale rocks. The number of many happy hours he spent here in company with Mr. Ashworth, of Hebden Bridge, the late Captain Aitkin, of Bacup, and the Author, might be attested, if need be, by the collection of fossils from this locality, of which he was always proud. About 1871 Mr. Spencer became especially interested in the study of the structure of fossil plants which occur in nodules derived from the Halifax Hard Bed Coal. At first he found this kind of work very difficult to perform, as he had to break the petrified stems of plants out of the hard nodules, then chip thin pieces off with a chisel, then rub them down on the sink-stone until they were so thin that light would shine through them. Then they had to be polished and mounted on glass with Canada balsam before the structure could be seen to advantage with a microscope. By this primitive and laborious method of preparing microscopic slides of fossil wood, Mr. Spencer worked disadvantageously for some time. At length he fortunately met with Mr. John Butterworth, of Shaw, near Oldham, who was an adept at this kind of work, having been for several years engaged in preparing and studying microscopic slides from the coal-balls of Lancashire. This gentleman kindly and unhesitatingly agreed to show him a more scientific and quicker method of preparing his slides, and he helped him to set up a machine for cutting and grinding. He also gave him instructions in the art of polishing, mounting, and preparing specimens for scientific use. Thus equipped, Mr. Spencer set to work with a determination to do something in the comparatively new field of research, and the success he achieved in that particular branch of science may easily be gleaned from the many hundreds of beautiful slides of Calamites, Lepidodendron, Sigillaria, Stigmaria, Fern Spores, Astromyelon, Dadoxylon, and other Coal Measure plants to be seen in his own cabinet, while a greater number have found their way into both private and public collections.

Mr. Spencer did not consider himself sufficiently versed in structural botany to be able to scientifically describe anything at first-hand, so that when he discovered any character in a fossil plant at all uncommon, however insignificant, he sent it to Professor Williamson, F.R.S., of Owens College, Manchester, who described it in his memoirs and always gave ample credit to the finder.

There can be no doubt that Mr. Spencer did good work and was the means whereby much was added to our knowledge of the Carboniferous Flora. The greatest find made by Mr. Spencer was at Bradshaw Pit, near Halifax, about eight years ago, where he came across a new species of club moss. This was described by Professor Williamson, who named it *Lepidodendron Spenceri*, in honour of the discoverer. Mr. Spencer contributed a series of articles to *Hardwick's Science Gossip*, which appeared from March, 1881, to July, 1883, entitled, "Recreations in Fossil Botany." They were based on his general work on the Carboniferous Flora, and were well illustrated. At the York meeting of the British Association, in 1881, he read two papers. He has also read several papers before the Yorkshire Geological and Polytechnic Society. Mr. Spencer studied the "Glacial Drift" in the Calder Valley and read papers on this important work. He was for some time curator of the Halifax Museum. He was continually adding to his collection of microscopic slides, and his love for geology was so deep-rooted that he pursued it to the end. His work was, however, unfortunately cut short just at a time when he had contemplated making a great improvement in cutting and grinding by adding a gas engine to his lathe. Contracting English cholera he died at his residence, No. 8, Salisbury Place, Akroydon, after an illness of only three days, on July 9th, 1898, in the sixty-fifth year of his age. He was interred in the cemetery of All Souls, Akroydon. R. Law.

SECRETARY'S REPORT, 1898.

A satisfactory state of affairs can be recorded for the present year of the Society's work. Two General Meetings and Field Excursions have been held as usual, but there has been a falling off in the attendance as compared with the previous two or three years.

The first meeting of the 1898 season was held at Clapham on June 10th and 11th, for the investigation of Ingleborough, Norber, and Crummack Dale. The members met on Friday morning, June 10th, at Clapham station, and proceeded by train to Ingleton. Then, under the leadership of Professor T. McKenny Hughes, F.R.S., F.G.S., of Cambridge, they proceeded up Dale Beck. The large quarries in the Mountain Limestone at Skirwith were noted, and the included patch of carbonaceous shale was pointed out by the leader, who also indicated the positions of the two faults which run across Ingleton, one bringing the Coal Measures of the small Ingleton Coalfield against the Mountain Limestone, and the second and parallel fault bringing down the Mountain Limestone against the Bala beds. On the hillside boulders of Silurian grit were seen resting on the limestone beds, and were pointed out as the remnants of masses of drift, the finer portions of which had been carried away by water. At the Ingleton granite quarries the party were met by Mr. John W. Tate, M.E., the manager, who courteously showed the members over the quarries and described the formation. This "granite" of commerce is much used for road metal, and is a tough, strong-grained rock of aqueous formation, the materials being in all probability derived from an adjacent volcanic district, and roughly assorted under water before consolidation. It includes beds of finer or slaty material, which are of no commercial value. Then a vigorous push was made for Ingleborough, the path up Ravenscar being taken. At the top of Ravenscar a short halt was called for lunch, and to examine the interesting clints or bare limestone tables which are so characteristic a feature of this district. Then the Professor pointed out the succession of Yoredale limestones and sandstones which make up the main of the higher part of Ingleborough, surmounted by the Upper Scar Limestone, over which comes the cap of Millstone Grit which forms the summit. After the summit had been reached the leader pointed out the evidences of the ancient encampment, which consisted of millstone grit flags set on end, against which smaller blocks had been heaped up. Refreshment having been obtained at an excellent spring at the base of the Millstone Grit, the downward journey, on the east side, was utilised for the examination of the limestone, containing *Producta gigantea* var. *latissima*, and an attempt was made to discover whether there was any specific difference between this variety and the normal form found at a lower level. After a short sojourn at Gaping Gill Hole, the return journey was taken by Trowgill to Clapham.

After dinner at the New Hotel, Clapham, the general meeting was held under the presidency of Professor Hughes. After the reading of the minutes, the following new members were elected:—Messrs. Chas. T. Whitmell (Leeds), Hymas (Ripon), Edgar D. Wellburn (Sowerby Bridge), W. Robinson (Sedburgh), W. Stewart (Wakefield), and J. W. Tate (Ingleton). Professor Hughes then delivered an address on the geology of the district, which he characterised as one of the most interesting in England. As one stood on the top of Ingleborough you could see the relics of one of the great ancient sea-plains. Dotted all round were hills of 2,000 ft. or thereabouts, the height of which was not determined by the hard capping band of Millstone Grit, for on the Howgill Fells the same general level was maintained, and right on to the Lake District. There you came on to a sudden uplift to 3,000 feet, the relics of a much older sea-plain. Also at the base of the Carboniferous Limestone all over the district there lay Cambrian and Silurian beds, which, though folded and uplifted, were cut off clearly to form a plain on which the Mountain Limestone had been deposited. These plains were called plains of marine denudation, but he preferred to call them plains of marine arrestation, the main work being done by rain, rivers, and frost, whilst the sea determined the level beyond which this action could not go, and plained away the final slice. Professor Hughes alluded to the contrast between the stretches of bare rock in some places, where the waves had been able to scour freely, and the pockets of conglomerate, where hollows had been ready to receive the débris. These pockets formed the basement beds of the Carboniferous so well seen in this district.

Attention was called by the Chairman, and also by Mr. P. F. Kendall (Leeds), to the interesting glacial phenomena of the neighbourhood and to the great systems of faults.

A paper on "The Millstone Grit and Yoredales of the Calder Valley" was read by Mr. James Spencer (Halifax). Mr. Spencer adduced evidence to show that there was no real palæontological break between the lower Yoredale beds and the Coal Measures, and described the arrangement of the strata along the course of the Calder from Halifax across the Pennine anticlinal.

A short paper on "Some Fish Remains found in the Yorkshire Millstone Grits" was read by Mr. Edgar D. Wellburn (Sowerby Bridge). The specimens of *Acanthodes Wardi* described consisted of the pectoral fin spine from Boulderclough, found by Mr. Thomas Saltenstall, of Sowerby, and others found by Mr. P. F. Kendall, at Eccup. The second species described was *Acrolepis Hopkinsi* which had been found in black shale about the centre of the Middle Millstone Grit at Eccup.

The second day's excursion consisted of an examination of Norber Brow and Crummack Dale. The route taken was along Thwaite Lane and up Norber Brow, in order to investigate the height to which the Silurian boulders have been carried by the ice which passed down Crummack Dale. Many Silurian grit boulders were found lying round the base of Norber in a long trail, which was probably a moraine of the glacier. From this point the boulders were traced across the bare limestone clints, and were found in great profusion on the lower ridges of Norber, lying in two or three parallel lines, which were evidently lateral moraines, but dwindling in numbers as the limestone hill was ascended. A careful search was made over the upper scars of Norber, with the view of ascertaining the highest point to which one of the Silurian boulders had been lifted by the ice. One was found near the flagstaff, the height being estimated, by aneroid observations, as 1,260 feet above O.D. Many others were found scattered about at a slightly lower level. On the lower scars many of these boulders are beautifully perched on limestone pedestals, about 18 inches in height. These boulders have protected the limestone on which they rest from the eroding action of the subaërial denuding agencies, and the height of the pedestal is a measure of the time since the boulder was left on the bare scar by the ice. Under some of these perched boulders the limestone was found to be beautifully grooved and striated, the groovings passing across the joints, and affecting the fossils on the surface and pointing directly up the dale. One of the heaviest boulders had fallen over and lay on a crushed mass of limestone, showing that its weight had become too much for the gradually weakened pedestal to bear, and it had given way. Several of the most interesting blocks were photographed.

The party then descended into Crummack Dale and examined the outcrop of the Austwick Grits, from which the Norber boulders had been derived. These grits form a ridge striking across Crummack Dale, which is part of the Silurian sea-plain on which the Mountain Limestone beds were laid down. Where hard grits existed this sea-plain was left in prominent ridges, whereas, where beds of shale or softer sandstones existed, intermediate hollows were left, and thus the base of the Mountain Limestone assumes an undulating form. The boulders increase rapidly in numbers as the outcrop of the Austwick Grits is approached. They were evidently masses torn off the grit beds on the dale side by the advancing ice, and are the result of its final efforts. Careful observations were taken of the highest point reached by the "live" rock, and this proved to be 1,210 feet above O.D. This showed that there had been a minimum uplift in the case of the highest boulders found, of 50 feet above the bed rock. This effectually disposed of a recently made assertion that the Norber boulders had not been lifted by the Crummack glacier.

The party continued up Crummack Dale to Beck Head, where a good supply of ice-cold water comes out of two small cave openings. Here an interesting double unconformity was examined. The Bala beds upturned are overlaid by a Silurian conglomerate, and over these uncomfortable strata the Mountain Limestone comes in horizontal sheets. The exposure of Moughton Whetstones under the shoulder of Moughton was examined, and then, after a photographic group had been taken by Mr. Godfrey Bingley, a return was made to Wharfe, near which the zone of *Phacops elegans*, and the underlying conglomerate at the base of the Silurian were examined. A rapid walk brought the party back to Clapham, where they dined together, and then separated with congratulations on two excellent days' work.

The second general meeting was held on Friday, July 15th, at Malton, and was associated with a two-days' field excursion over the country between Malton and the Wolds.

On Friday, July 15th, the party travelled to Burdale Station, where they were met by the Rev. E. Maule Cole, M.A., the leader, and Mr. J. R. Mortimer. Just outside Burdale Station the position of the Red Chalk was pointed out, showing that the chalk had been cut through to its base. Fairy Dale was ascended, and the interesting Fairy Stones which stand at its head were examined. These are composed of a breccia of chalk and flints firmly cemented together, and the leader pointed out evidence that a similar rock extends for some distance in a straight line, and explained the peculiar conditions observed as due to a fissure in the chalk which had been filled in by flints and chalk fragments and then consolidated by the deposition of a firm calcareous cement. The route thence was over the tunnel top above Raisthorpe, to see some curious hollows in the chalk, which may have been caused by earth movements analogous to landslips, as they lie fairly parallel to the adjacent valley. Back Dale was then gained and the series of landslips along its sides noted. It had been intended to climb the hill above Thixendale for a view of Water Dale, which is a most impressive example of the interesting Wold scenery, but the heat of the day and a paucity of time necessitated the omission of that detour. A move was made for Aldro, and the famous tumuli and entrenchments which have made this locality famous were examined. After luncheon and a welcome rest the party proceeded to Leavening, enjoying a splendid view over the Vale of York and noting the various interesting features of the western escarpment of the Secondary beds. Having left the edge of the Chalk Wolds, the party made a cross-country traverse through pleasantly-varied Jurassic scenery to Kirkham Abbey, where the 5.43 train was taken to Malton. The members dined together at the Talbot Hotel, and, after dinner, the general meeting was held under the presidency of Sir Charles W. Strickland, Bart. The Chairman gave a genial address on the geological features of the neighbourhood. He referred to many of the pits in the Coralline Oolite which were formerly worked, but had been closed for many years, and to their interesting fossil contents. Referring to the many separated knolls of the limestone along the outcrop of the Coralline Oolite beds, he said that he did not consider this separation as mainly due to denudation, but that these were separated coral islets originally.

A paper on "The so-called British Habitations on Danby North Moor," by Mr. J. R. Mortimer, was read by the Rev. E. Maule Cole, M.A., and followed by a vigorous discussion. Short papers were also read by the Rev. E. Maule Cole, on "The Distribution of Moorlands in the East of Yorkshire, as explained by the Glacial History of the County," and on "Brunanburh." Some of the points raised were referred to by the members present, and the Rev. E. Maule Cole replied.

A vote of respectful condolence with the family of the late Mr. James Spencer, of Halifax, who died suddenly from an attack of English cholera, on July 9th, 1898, was passed. Mr. Spencer's careful and industrious labours, especially in the investigation of the fossil plants of the Halifax Coal Measures, were referred to by several of the members, and feeling allusions were made to the loss which Yorkshire geology has sustained by his decease.

The second day's excursion, on Saturday, July 16th, was devoted to fossil hunting in the rich coralline beds of Settrington and North Grimston. Numbers of fine corals and other characteristic fossils were obtained, and the day was completed by a visit to the Chalk Quarries at Ludwith. Before the members separated, a hearty vote of thanks was given to the Rev. E. Maule Cole, M.A., for his genial and instructive leadership.

The Council much regret to have to report the decease since our last annual meeting, of three members; Mr. Stephen Seal, F.G.S., of the Darfield Quarries, who joined the Society in 1869, the Rev. J. Stanley Tute, B.A., Vicar of Markington, who since 1875 has been a valued investigator of Yorkshire geology, and who has contributed several valuable papers to our Proceedings, and Mr. Edward Brooke, F.G.S., of Huddersfield.

The position of Local Secretary for Huddersfield, which has been vacant since the lamented death of Mr. Joseph Field, has now been filled by the acceptance of the office by Mr. Samuel Jury.

Our Proceedings, Vol. XIII., Part 3, was issued during the summer, and contained, in addition to several valuable papers, a series of excellent views of Filey Bay and Brigg, reproduced from the negatives of Mr. Godfrey Bingley, to whom the best thanks of the Council are due. It is hoped that Part 4, which will complete Vol. XIII., will be published and issued to the members in the spring of 1899.

With regard to next year's general meetings and excursions, the Council suggest that the following centres should be chosen:—Middlesbrough with excursions in Cleveland, and Upper Calderdale with headquarters at Todmorden, or the district round Clitheroe.

The Council desire to acknowledge with best thanks, the receipt of a parcel of books and pamphlets for the library from Mr. William Whitaker, P.G.S., F.R.S. As usual our Proceedings have been forwarded to leading scientific societies in all parts of the world, and exchanges of their publications in return have been received from the following societies:—

Royal Geological Society of Cornwall, Penzance.
Royal Institution of Cornwall, Truro.
Royal Physical Society of Edinburgh.
Royal Geographical Society, London.
Royal Dublin Society.
British Association, London.
Geological Society of London.
Bristol Naturalists' Society.
Cambridge Philosophical Society.
Essex Naturalists' Field Club.
Leeds Geological Association.
Liverpool Geological Society.
Manchester Geological Society.
Manchester Geographical Society.
Manchester Literary and Philosophical Society.
Edinburgh Geological Society.
Geologists' Association, London.
Glacialists' Association, Leeds.
Hertfordshire Natural History Society.
Yorkshire Philosophical Society.
Comité Geologique de la Russie, St. Petersburg.
Sociedad Cientifica "Antonio Alzate," Mexico City.
Royal University Library, Upsala.
Royal University of Norway, Christiania.
L'Académie Royale des Sciences et des Lettres de Danemark, Copenhagen.
L'Académie Royale Suédoise des Sciences, Stockholm.
Museu Nacional do Rio de Janeiro.
Academy of Natural Sciences, Philadelphia, U.S.A.
American Philosophical Society, Philadelphia, U.S.A.
American Museum of Natural History, New York.
Boston Society of Natural History, U.S.A.
Elisha Mitchell Scientific Society, North Carolina.
New York Academy of Sciences.
Smithsonian Institution, Washington.
United States Geological Survey, Washington.
Museum of Comparative Zoology at Harvard College.
Kansas University, Lawrence, Kansas.
Department of Mines, Sydney, N.S.W.
Australian Institute of Mining Engineers, Melbourne.
Nova Scotian Institute of Science, Halifax.

W. Lower Carter.

THE YORKSHIRE GEOLOGICAL AND POLYTECHNIC SOCIETY.

Statement of Receipts and Expenditure, 1st November, 1897, to 15th November, 1898.

REVENUE ACCOUNT.

1898. **Receipts.**	£	s.	d.
To Balance in Treasurer's hands, 1st November, 1897	1	4	1
,, Transfer from Capital Account ...	18	18	0
,, Subscriptions...	86	6	0
,, Sale of Proceedings	7	16	3
,, Halifax Corporation Interest ...	10	3	0
,, Balance due to Treasurer	0	15	11
	£125	3	3

1898. **Expenditure.**	£	s.	d.
By Whitley & Booth, printing Proceedings. Balance to close account	43	17	0
,, Jas. Green, Drawing Plates for Fossil Fish	11	0	0
,, Morgan & Kidd, collotype prints ...	8	16	4
,, F. Carter, Stationery, &c.	16	8	0
,, Mintern Bros., Lithography	6	10	0
,, Expenses of Meetings	8	11	5
,, Petty Cash and Postages	7	6	3
,, Chorley & Pickersgill, on account, printing Proceedings	20	0	0
,, Chorley & Pickersgill, Postage of Proceedings	2	14	3
	£125	3	3

CAPITAL ACCOUNT.

To Life Members' Subscriptions ...	£18	18	0	By Transfer to Revenue Account ...	£18	18	0
To Halifax Corporation Bond ...	£350	0	0	Audited 15th December, 1898. GEO. PATCHETT.			

RECORDS OF MEETINGS.

Council Meeting, Philosophical Hall, Leeds, Dec. 16th, 1897.

Chairman :—Mr. Richard Reynolds, F.C.S.

Present :—Messrs. G. Bingley, F. W. Branson, J. E. Bedford, H. Crowther, J. J. Wilkinson, J. H. Howarth, P. F. Kendall, and W. L. Carter (Hon. Sec.).

The minutes of the previous Council Meeting were read and confirmed.

Letters of regret for non-attendance were read from Messrs. W. Gregson, W. Simpson, and W. Cash.

Printing of Proceedings.—In accordance with the resolution of the Council the Secretary presented estimates from three Leeds firms for the printing of the Proceedings. It was resolved that the lowest tender, that of Messrs. Chorley & Pickersgill, be accepted. Carried unanimously.

The question of the plates to illustrate the Proceedings, Vol. XIII., Part 3, was then considered. The Sub-Committee appointed to consider the issue of a series of photographs reported that they had decided to recommend that eight photographs of Filey Bay, Filey Brigg, and Carr Naze should form the series for the next issue.

The report was unanimously adopted.

Council Meeting, Philosophical Hall, Leeds, April 21st, 1898.

Chairman :—Mr. Richard Reynolds, F.C.S.

Present :—Messrs. C. W. Fennell, G. Bingley, F. F. Walton, H. Crowther, J. J. Wilkinson, and W. L. Carter (Hon. Sec.).

Letters of regret for non-attendance were read from Messrs. P. F. Kendall and J. H. Howarth.

The minutes of the previous Council Meeting were read and confirmed.

The Secretary presented a report of the state of the printing of the Proceedings, Vol. XIII., Part 3, and exhibited proofs of the plates already produced.

The Secretary reported that he had forwarded a letter of condolence to the widow and family of the late Rev. J. Stanley Tute, B.A., of Markington, an old member of our Society and a valued investigator of Yorkshire geology. This action was approved by the Council.

Excursions. — The Secretary reported that the districts suggested for visitation by the Society this year were Clapham and the Wolds.

After some discussion it was resolved that General Meetings and Field Excursions should be held at:—

(1.) Clapham, for Ingleborough and Crummack Dale, on June 10th and 11th, Professor T. McKenny Hughes, F.R.S., to be invited as leader.

(2.) Malton, for the Wolds, on July 15th and 16th, the Rev. E. Maule Cole, F.G.S., to be the leader.

(3.) That an effort be made to hold the Annual Meeting at Pontefract, coupled with a visit to Fryston Hall.

Appointments.—The Hon. Secretary reported that he had asked Mr. Samuel Jury to undertake the position of Local Secretary for the Huddersfield district, and that Mr. Jury had expressed his willingness to fill the vacant post. This appointment was confirmed.

The Rev. W. Lower Carter, M.A., F.G.S., was elected by ballot Representative Governor of the Yorkshire College; Mr. Wm. Cash, F.G.S., was appointed delegate to the meeting of the British Association at Bristol.

The letter of the Sanitary Institute asking for the appointment of two delegates to their meeting at Birmingham, in September, was read, and the nomination of delegates was left in the hands of the Hon. Secretary.

It was resolved that a copy of Bibliographia Geologica, I (1898), by M. Mourlon, Director of the Service Géologique of Belgium (5 fr.) should be purchased for the library.

The following account was passed for payment:—Morgan and Kidd, for plates, £8 16s. 4d.

General Meeting and Field Excursion at Clapham, June 10th and 11th, 1898.

On Friday, June 10th, the members met at Clapham Station and proceeded by train to Ingleton. The party, led by Professor T. McKenny Hughes, F.R.S., went up Dale Beck, stopping to notice the Skirwith limestone quarry, and the blocks of Silurian grit scattered over the hillside. Two or three fine sections of the junction of the Carboniferous Limestone with the Bala beds were noticed by the roadside, and a visit was paid to the Ingleton granite quarry. Here the party was met by Mr. Jno. W. Tate, the manager, who courteously showed the various features of the workings. A rapid ascent was then made to Ravenscar, and a halt was called for lunch on the limestone clints. The leader pointed out the various beds which cropped out on the face of Ingleborough, and the ascent was then made. On the summit, the evidences of its enclosure as a camp were pointed out. On the downward journey the Upper Scar Limestone under Simonside was examined, and a visit was paid to Gaping Ghyll Hole. Thence the party returned to Clapham by way of Trowgill.

The general meeting was held after dinner at the New Hotel, Clapham, under the presidency of Professor T. McKenny Hughes, M.A., F.R.S., F.G.S., of Cambridge. Present, 21.

The minutes of the annual meeting were read and confirmed.

The following new members were elected:—

Edgar D. Wellburn, L.R.C.P., Sowerby Bridge.
William Robinson, Sedbergh.
William Stewart, Wakefield.
Jno. W. Tate, M.E., Ingleton.
Charles T. Whitmell, M.A., Leeds.
Mr. Hymas, Ripon.

An address on the Geology of Clapham and district was delivered by the Chairman.

A paper was read by Mr. James Spencer on "The Yoredale and Millstone Grit Rocks of the Upper Calder Valley, and their Fossils."

A paper was read by Mr. Edgar D. Wellburn, L.R.C.P., on "Some Fish Remains found in the Yorkshire Millstone Grits."

A short discussion followed.

A hearty vote of thanks was passed to Professor Hughes and to the readers of the papers.

June 11th.—The party, under Professor Hughes's guidance, ascended Norber Brow and investigated the height to which the Silurian boulders had been elevated by the ice. The trail of boulders was followed up to the outcrop of the Austwick Grits in Crummack Dale, and the height of the highest exposure was noted. This showed a minimum rise of 50 feet for the highest boulder observed. Crummack Dale was then ascended to Beck Head, and an interesting double unconformity of the Bala beds, Silurian conglomerate, and Mountain Limestone was examined. A move was then made to the north-east corner of the dale to obtain specimens of the Moughton Whetstones. On the return journey a brief halt was made at Wharfe to examine the zone of *Phacops elegans* and the underlying Silurian conglomerate. After dinner at the New Hotel the party separated with mutual congratulations on two very interesting days' work.

General Meeting and Field Excursion at Malton, July 15th and 16th, 1898.

The party met the Rev. E. Maule Cole, M.A., F.G.S., the leader, at Burdale Station. The position of the Red Chalk near the bottom of the dale was pointed out, and the Fairy Stones visited. Thence the party walked to Back Dale, and noted the landslips along the dale side. At Aldro a halt was called for lunch, and the noted entrenchments were examined. During the descent to Leavening the leader pointed out the interesting scenic features caused by the outcrop of successive members of the Oolites along the escarpment of the Wolds. A cross-country tramp brought the party to Kirkham Abbey Station, where the train was taken to Malton.

The general meeting was held at the Talbot Hotel, Malton, under the presidency of Sir Charles Strickland, Bart. Present 16.

The minutes of the previous General Meeting were read and confirmed.

The following new member was elected:—H. Mainwaring Holt, M.R.C.S., Medical Officer of Health, Malton.

An address was given by Sir Charles Strickland, Bart., on the Coralline Oolite of the neighbourhood of Malton.

A paper on "The So-called British Habitations on Danby North Moor," by Mr. J. R. Mortimer, was read by the Rev. E. Maule Cole, M.A., F.G.S.

Papers on "The Distribution of Moorlands in the East of Yorkshire, as explained by the Glacial History of the County," and on "Brunanburh," were read by the Rev. E. Maule Cole.

Various points in the papers were discussed by Messrs. Hawell, Carter, Slater, Robinson, Stather, and Holt. The Rev. E. Maule Cole replied.

A vote of respectful condolence with the family of the late Mr. James Spencer, of Halifax, deceased July 9th, 1898, was passed. Mr. Spencer's careful and industrious labours, especially in the investigation of the Halifax Coal Measures, were alluded to by several of the members.

A vote of thanks to the Chairman, the Leader, and the Readers of Papers, was passed unanimously.

On July 16th the party visited the quarries of Coralline Oolite, at Settrington and North Grimston, under the guidance of the Rev. E. Maule Cole.

Council Meeting, Philosophical Hall, Leeds, September 29th, 1898.

Chairman:—Mr. Godfrey Bingley.

Present:—Messrs. J. T. Atkinson, W. Cash, H. Crowther, J. J. Wilkinson, P. F. Kendall, F. W. Branson, J. E. Bedford, and W. L. Carter (Hon. Sec.).

The minutes of the previous Council Meeting were read and confirmed.

Letters of regret for non-attendance were read from Messrs. W. Simpson, C. E. Fennell, and J. H. Howarth.

Annual Meeting.—A letter was read from Lord Ripon with reference to the annual meeting. A letter was read from Lord Crewe regretting that he could not fix a date earlier than the end of October for a visit to Fryston, but, in case that would be convenient, offering the members his hospitality.

After some discussion it was felt that this date would be rather late for a meeting at Pontefract, and it was resolved to ask Lord Crewe for permission to hold over his invitation for another year.

It was resolved that the annual meeting be held at Leeds. November 17th was suggested as a suitable date. The Secretary read an abstract of the report, which was approved.

Officers and Council.—A letter was read from Mr. Arnold Lupton, F.G.S., resigning his seat on the Council on account of removal from Leeds.

The list of Officers and Council was submitted, and it was decided to nominate Mr. Edgar D. Wellburn, L.R.C.P., of Sowerby Bridge, for the vacant seat on the Council, and Mr. William Whitaker, P.G.S., F.R.S.,as an Honorary Member of the Society.

The Hon. Secretary was instructed to prepare a nomination paper for the annual meeting, as was done last year.

Grassington Finds. — A report was received from Mr. A. Dodgson of the unsatisfactory state of the "Finds," at Grassington, belonging to the Society.

Mr. J. J. Wilkinson reported that the three trustees appointed by the Society (Messrs. J. R. Eddy, F.G.S., E. T. Hartley, M.A., and J. J. Wilkinson), had done their best to arrange for the amalgamation of Mr. Bailey Harker's collection with that of this Society, but owing to local difficulties that had been found, up to the present, impracticable. They felt that their position was very unsatisfactory, and tendered their resignations.

After some discussion it was resolved that the Secretary arrange with some competent person to pack up the specimens and have them conveyed to Leeds for exhibition at the annual meeting.

The following accounts were passed for payment:—

	£	s.	d.
Chorley & Pickersgill—Proceedings ...	33	12	0
J. Green—Drawing Plates	11	0	0
Mintern Bros.—Lithographing	6	10	0
F. Carter—Circulars and Stationery ...	4	14	0
	£55	16	0

Next Year's Meetings.—A letter was read from Rev. J. Hawell, M.A., F.G.S., suggesting that a meeting should be held in the Cleveland District. This suggestion was adopted.

For the other general meeting and field excursion an examination of Upper Calderdale was suggested.

Proceedings, Vol. XIII., Part 4.—A list of papers ready for publication was given by the Hon. Secretary.

Mr. G. Bingley reported that he had not yet been able to complete his photographs of the coast north of Filey Brigg, but hoped to be able to do so during the next summer. It was, therefore, agreed that views should be issued to illustrate Mr. Kendall's paper on the Wharfe and Nidd, or the excursion to Clapham.

Annual General Meeting, Philosophical Hall, Leeds, Nov. 17th, 1898.

In the absence of the President the chair was taken by Arthur Smith Woodward, Esq., F.G.S., F.L.S.

The Hon. Secretary read a letter from Lord Ripon regretting his inability to be present and preside.

The Hon. Secretary read the report for 1898, and the Treasurer presented the financial statement, which were unanimously adopted.

The following new members were elected.

John Nevin, J.P., Littlemoor, Mirfield.
William Story, Fewston, near Otley.
Robert Law, F.G.S., Hipperholme.
George W. Haldane, Wakefield.

On the recommendation of the Council, William Whitaker, P.G.S., F.R.S., was elected an Honorary Member of the Society.

The following Officers and Members of Council were elected on the proposition of Mr. C. T. Whitmell, M.A., seconded by Mr. J. W. Sutcliffe:—

President:

The Marquis of Ripon, K.G.

Vice-Presidents:

Earl Fitzwilliam, K.G.
Earl of Wharncliffe.
Earl of Crewe.
Viscount Halifax.
H. Clifton Sorby, LL.D., F.R.S.
Walter Morrison, M.P.
W. T. W. S. Stanhope, J.P.
James Booth, J.P., F.G.S.
F. H. Bowman, D.Sc., F.R.S.E.
Richard Reynolds, F.C.S.
W. H. Hudleston, F.R.S.
J. Ray Eddy, F.G.S.
David Forsyth, D.Sc., M.A.

Treasurer:

William Cash, F.G.S.

Hon. Secretary:

William Lower Carter, M.A., F.G.S.

Council:

J. T. Atkinson, F.G.S.
J. E. Bedford, F.G.S.
Godfrey Bingley.
F. W. Branson, F.I.C.
J. H. Howarth, F.G.S.
P. F. Kendall, F.G.S.
G. H. Parke, F.L.S., F.G.S.
R. Reynolds, F.C.S.
W. Rowley, F.G.S.
J. Stubbins, F.G.S.
F. F. Walton, F.G.S.
E. D. Wellburn, L.R.C.P.

Local Secretaries:

Barnsley—T. W. H. Mitchell.
Bradford—J. E. Wilson.
Driffield—Rev. E. M. Cole, M.A., F.G.S.

Halifax—W. Simpson, F.G.S.
Harrogate—Robert Peach.
Huddersfield—Samuel Jury.
Hull—John W. Stather, F.G.S.
Leeds—H. Crowther, F.R.M.S.
Middlesbrough—Rev. J. Hawell, M.A., F.G.S.
Skipton—J. J. Wilkinson.
Thirsk—W. Gregson, F.G.S.
Wakefield—C. W. Fennell, F.G.S.
Wensleydale—W. Horne, F.G.S.

The following papers were read and discussed:—

"Some Notes on Yorkshire Caves" (continued), by Mr. S. W. Cuttriss, illustrated by Lantern Slides.

"Notes on some Physical Features in Iceland," by Mr. Charles W. Fennell, F.G.S.

"On Extra-morainic Lakes and River-courses in Yorkshire," by Mr. P. F. Kendall, F.G.S., illustrated by Lantern Slides.

"On the recent Pre-historic Finds in the neighbourhood of Todmorden," by Mr. Robert Law, F.G.S.

"On Boulder-like Stones in a Leeds Cutting," by Mr. B. Holgate, F.G.S.

"On the Fish Fauna of the Lower Coal Measures of the Halifax and Littleborough Districts," by Mr. Edgar D. Wellburn, L.R.C.P.

"On the Fossil Fishes of the Upper Lias of Whitby, Part IV.," by Mr. Arthur Smith Woodward, F.L.S., F G.S.

A series of lantern slides illustrative of the 1898 excursions was exhibited by Mr. Godfrey Bingley and the Rev. W. Lower Carter, M.A.

The following resolution was proposed by Mr. Richard Reynolds, F.C.S., seconded by Professor L. C. Miall, F.R.S., and carried unanimously:—"That the best thanks of the Society be given to the President, Treasurer, and Honorary Secretary for their conduct of the affairs of the Society during the past year."

The following resolution was proposed by the Rev. C. T. Pratt, M.A., seconded by Mr. J. E. Wilson, and carried unanimously:—"That the best thanks of this Society be given to the Chairman for presiding, to the Leeds Literary and Philosophical Society for the use of their library, to the Readers of Papers and Leaders of Excursions, and to Messrs. Reynolds & Branson for the lantern."

The members dined together at the Queen's Hotel, under the presidency of Mr. Arthur Smith Woodward, F.L.S., F.G.S.

After dinner, by invitation of the Leeds Geological Society, the members attended the meeting of that Society at the Leeds Institute, Cookridge Street, and listened to an interesting lecture by Mr. Percy F. Kendall, F.G.S., on "Geology at the British Association."

In connection with the annual meeting the following field excursions were arranged:—

On November 17th, a party was led by Mr. B. Holgate, F.G.S., to view some interesting concretions in the Coal Measures in the Midland Railway cutting at Hunslet.

On November 18th, a small party was met at Churwell Station by Mr. L. Trench, engineer, London and North-Western Railway, and conducted by him over the new line between Farnley and Birstall. A hearty vote of thanks was passed to Mr. Trench for his courtesy and kind leadership.

HONORARY MEMBERS.

1887 BODINGTON, Principal N., Litt.D., The Yorkshire College, Leeds.

1892 DE RANCE, CHAS. E., C.E., F.R.M.S., 55, Stoke Road, Skelton, Stoke-on-Trent.

1887 HUGHES, Prof. T. McK., M.A., F.R.S., F.G.S., Hills Road, Cambridge.

1887 JUDD, Prof. JNO. W., C.B., LL.D., F.R.S., F.G.S., Science Department, South Kensington, London.

1887 WOODWARD, HENRY, LL.D., F.R.S., British Museum (Natural History), Cromwell Road, London, S.W.

1898 WHITAKER, WILLIAM, B.A., P.G.S., F.R.S., Freda, Campden Road, Croydon.

LIST OF MEMBERS.

Life members who have compounded for the Annual subscriptions are indicated by an asterisk (*)

Elected.

1883*ABBOTT, R. T. G., Whitley House, Malton.

1875 ATKINSON, J. T., F.G.S., Hayesthorpe, Holgate Hill, York.

1890*ACKROYD, W., F.I.C., Borough Analyst, Halifax.

1899 ANNIS, ERNEST G., L.R.C.P., Medical Officer of Health, Huddersfield.

1899 ABBEY & HANSON, Surveyors, Huddersfield.

1879*BARTHOLOMEW, C. W., Blakesley Hall, near Towcaster.

1899 BEAN, J. A., South Parade, Wakefield.

1875 BEDFORD, JAMES, Woodhouse Cliffe, Leeds.

1878 BEDFORD, J. E., F.G.S., Arncliffe, Shire Oak Road, Headingley, Leeds.

1895 BINGLEY, GODFREY, Thorniehurst, Shaw Lane, Headingley, Leeds.

1875*BOOTH, JAMES, J.P., F.G.S., Spring Hall, Halifax.

1899 BOULD, CHAS. H., 5, Wrangthorn Place, Hyde Park, Leeds.

1876*BOWMAN, F. H., D.Sc., F.R.A.S., F.C.S., F.G.S., Mayfield, Knutsford, Cheshire.

1896 Bradley, F. L., Bel Air, Alderley Edge, Cheshire.
1894 Branson, F. W., F.I.C., 14, Commercial Street, Leeds.
1875*Brigg, John, M.P., F.G.S., Keighley.
1875*Briggs, Arthur, J.P., Cragg Royd, Rawdon, Leeds.
1897 Broughton, J. W., Architect, Skipton.
1877 Brooke, Sir Thos., Bart., J.P., Armitage Bridge, Huddersfield.
1887 Brownridge, C., C.E., F.G.S., 26, North Road, Devonshire Park, Birkenhead.
1882*Buckley, George, jun., Waterhouse Street, Halifax.
1896 Burrell, B.A., F.I.C., F.C.S., 5, Mount Preston, Leeds.
1892*Carter, W. Lower, M.A., F.G.S., Hopton, Mirfield.
1876*Cash, W., F.G.S., 35, Commercial Street, Halifax.
1891*Chambers, J. C., 7, Cardigan Road, Headingley, Leeds.
1875*Charlesworth, J. B., J.P., Hurts Hall, Saxmundham.
1892 Child, Hy. Slade, F.G.S., Mining Engineer, Wakefield.
1877*Clark, J. E., B.A., B.Sc., 112, Wool Exchange, London, E.C.
1878 Cole, Rev. E. Maule, M.A., F.G.S., Wetwang Vicarage, near York.
1889 Crewe, Earl of, Fryston Hall, Pontefract.
1897 Crofts, William Hastings, 60, Freehold Street, Hull.
1899 Crossley, Abraham, 62, Wellington Road, Todmorden.
1894 Crowther, Henry, F.R.M.S., The Museum, Leeds.
1899 Dalzell, A. E., 3, Wesley Court, Crossley Street, Halifax.
1879*Dakyns, J. R., M.A., of H.M. Geological Survey, 28, Jermyn Street, London, W.
1883 Dalton, Thos., 65, Albion Street, Leeds.
1894*Davis, James Percy A., Chevinedge, Halifax.
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1894 Embleton Henry C., Central Bank Chambers, Leeds.

1895 Farrah, John, F.R.Met.S., Jefferies Coate, York Road, Harrogate.

1887*Fennell, Chas. W., F.G.S., 82, Westgate, Wakefield.

1839 Fitzwilliam, Earl, K.G., Wentworth Woodhouse, near Rotherham.

1883*Fleming, Francis, Elm Grove, Halifax.

1893 Forsyth, David, D.Sc., M.A., 2, Lifton Place, Leeds.

1894 Fox, C. E., P.A.S.I., 22, George Street, Halifax.

1891*Furness, Sir Christopher, Brantford, West Hartlepool.

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1898 Haldane, George W., M.E., Old Corn Exchange, Wakefield.

1843 Halifax, Viscount, Hickleton Hall, Doncaster.

1878 Hallilay, J., 28, Burley Road, Leeds.

1895 Harker, Alfred, M.A., F.G.S., St. John's College, Cambridge.

1895 Hartley, Edward Tomson, M.A., The Grammar School, Skipton.

1887 Hastings, Geoffrey, 15, Oak Lane, Bradford.

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1895*Imbery, John, Hyde Park Road, Halifax.

1887*Jones, J. E., Solicitor, Halifax.

1897 Jowett, Albert, B.Sc., 7, Grimthorpe Terrace, Headingley, Leeds.

1885 Jury, Samuel, Eleanor Street, Fartown, Huddersfield.
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1892 Kendall, Percy F., F.G.S., 5, Woodland Terrace, Chapel-Allerton, Leeds.
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1877*Lamplugh, G. W., F.G.S., of H.M. Geol. Survey, 28, Jermyn Street, London, W.
1894 Law, Arthur W., Greetland, Halifax.
1898 Law, Robert, F.G.S., Fennyroyd Hall, Hipperholme.
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1897 Millward, Adam, 5, Cambridge Crescent, Harrogate.
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1889 Mitchell, T. W. H., Barnsley.
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1891 Morton, J. H., Broad Street, Halifax.
1894 Muff, Herbert B., Aston Mount, Heaton, Bradford.
1895 Muller, Harry, 12, West Chislehurst Park, Eltham, Kent.
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1883 Peach, Robert, James Street, Harrogate.
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1882 Scarborough Philosophical Society, The Museum, Scarborough.
1897 Sheppard, Thomas, 78, Sherburn Street, Hull.
1892*Simpson, W., F.G.S., The Gables, Halifax.
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1887 Slater, M. B., 84, Newbiggin, Malton.
1899 Slater, A. C., B.Sc., Jesmond House, West Parade, Pudsey.
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1898*Stewart, William, Milnthorp House, Wakefield.
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1878 Strangways, C. Fox, F.G.S., Abbotsbury House, New Walk, Leicester.
1879*Strickland, Sir Charles W., Bart., Hildenly, Malton.
1894 Sutcliffe, J. W., 27, West View, Halifax.

1888 Sykes, Sir Tatton, Bart., Sledmere House, near York.
1898 Tate, Jno. W., M.E., Ingleton, Kirkby Lonsdale.
1897*Teal, Joseph, Grange Terrace, Yeadon, near Leeds.
1894 Tetley, Ed. H., B.A., Foxhills, Weetwood, Leeds.
1880 Tetley, C. F., M.A., Spring Road, Headingley, Leeds.
1886 Thompson, R., Drincote, The Mount, York.
1894 Thornton, Arthur, M.A., The Grammar School, Bradford.
1875*Tiddeman, R. H., M.A., F.G.S., of H.M. Geological Survey, 28, Jermyn Street, London, W.
1897 Tindall, George Fawcett, York Road, Tadcaster.
1899*Turton, Robert B., Kildale Hall, Grosmont, Yorks., R.S.O.
1884*Walmisley, A. T., C.E., F.S.I., F.K.C., 5, Westminster Chambers, Victoria Street, London.
1899 Walshaw, Thomas, Lincoln Street, Wakefield.
1894 Walton, F. Fielder, F.G.S., L.R.C.P., 19, Charlotte Street, Hull.
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1840 Wheatley, Charles, Sands House, Mirfield.
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1881*Whiteley, Fredk., Clare Road, Halifax.
1898 Whitmell, Chas. T., M.A., Invermay, Headingley, Leeds.
1896 Wigham, Frederick Henry, F.G.S., The Towers, St. John's, Wakefield.
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1890 Wilson, Edmund, Denison Hall, Leeds.
1894 Wilson, J. E., Yew Bank House, Ilkley.
1897 Wilson, J. Mitchell, M.D., 51, Hall Gate, Doncaster.
1878 Woodhead, Joseph, J.P., Longdenholme, Huddersfield.

⁂ It is requested that Members changing their residences will communicate with the Secretary.

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